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SIZE OF SOYBEAN OIL MILLS AND RETURNS TO GROWERS

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Agricultural Marketing Service
Marketing Research Division
Washington 25, D. C.

Marketing Research Report No. 121 November 1956

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SIZE OF SOYBEAN OIL MILLS AND RETURNS TO GROWERS

By John M. Brewster and Julia A. Mitchell, *agricultural economists, Marketing Research Division, Agricultural Marketing Service,* and Stanley P. Clark, *associate research engineer, Cottonseed Products Research Laboratory, Texas Engineering Experiment Station*

SUMMARY

This study determines the way in which change in the size of solvent soybean oil mills under typical operating conditions is related to corresponding change in total cost and total revenue per bushel of beans processed. The study then compares the efficiencies of different-size mills as measured by net revenue per bushel of beans and per dollar of investment. The net returns per dollar of investment are then used in determining to what extent, if any, farmers might be benefited, in the form of higher prices for their soybeans, from industrywide changes in the sizes of soybean oil mills. The study also seeks to determine the approximate point in the range of mill sizes at which solvent mills come to earn more net revenue per bushel of beans and per dollar of investment than screw-press mills.

A subsidiary objective of the study was to determine the approximate point in the range of mill sizes at which solvent mills come to gain a competitive advantage over screw-press mills.

To place all mills on a comparable basis with respect to depreciation, interest, property taxes, and insurance, model mills were developed through the use of engineering methods. Operating requirements and practices of these model mills were checked for reasonableness against those of well-operated actual mills. These models were assumed as operating under average conditions with respect to costs per unit of input, transportation cost of soybeans, the proportions of bulk and bagged meal produced, and f. o. b.-mill returns for oil and meal. It was also assumed that they operated at normal daily processing rates and for a 12-month season of 330 24-hour working days.

The main findings were as follows:

(1) Assuming the availability of soybeans, increasing the size of solvent mill from 50 to 1,000 tons of beans processed per 24-hour day resulted in a savings in cost of nearly 9 cents per bushel of beans, or $3 per ton. A saving of nearly 4 cents per bushel was accomplished by increasing the size of mill from 50 to 100 tons per day. An increase from 50 to 400 tons per day showed a saving of about 7 cents per bushel. Between 400 and 1,000 tons, there was a savings of 2 cents per bushel.

(2) With increase in the size of mill, meal revenue per bushel and total cost per bushel declined together and in approximately equal amounts. Oil revenue per bushel was assumed to be the same for all sizes of mills, since they have the same oil yield and receive approximately the same price per pound of oil.

The decline in meal revenue per bushel arose from the fact that the larger mill sells a greater proportion of its meal in the general, rather than local, market where the f. o. b. mill price is lower. The price for meal sold in an isolated local market is higher than for meal sold in the general market, because of freight costs on competitive inbound meal from other locations. Because of lower mill costs, large mills can afford to sell meal at a lower price then can smaller ones so long as the volume of beans processed is consistent with the capacity of the mills.

(3) Even though different-size mills made approximately the same net revenue (or loss) per bushel of beans, the larger mill made more profit per dollar of investment because it requires less investment per bushel of beans processed. For example, as calculated with 3 years' data (1951–52 through 1953–54), the difference in profit between a 150– and a 1,000-ton mill was 4.5 cents per dollar of investment. This was equivalent to 2.4 cents per bushel of beans. As the size of mill was varied downward from 1,000 tons per day, its differential profit over the 150-ton mill also fell, being only 0.16 cent per bushel for the 200-ton mill. In the present competitive situation, the bigger mill could use its bigger profit to bid up the price of beans until its return per dollar of investment fell to that of the smaller mill. The higher the basic profit level on which the industry is competing with other industries, the greater is this differential ability of the large mill to pay more for beans.

(4) Compared with the actual industry of various sizes of mills, the extent to which an industry of only 1,000-ton mills or over could raise the price of soybeans would be substantially less than 2.4 cents per bushel.

(5) While no reorganization of the industry into fewer but bigger mills could raise the price of beans appreciably, any reorganization of the industry into a larger number of smaller mills would result

in either a higher price for soybean meal or a lower price for soybeans, or both. Soybean production is highly concentrated relative to the area of the general market for soybean meal where the f. o. b.-mill price is lower than the local market price. To increase the number of small mills with advantages equivalent to those of present small mills would require extensive additional local markets. Such expansion of local markets is not possible. Local meal demand in the soybean belt is already being largely supplied by local mills.

(6) The study shows that as the size of the little mill is increased to approximately 50 tons per day, solvent mills come to earn more net revenue per bushel of beans and per dollar of investment than screw-press mills. At this point, the advantage of the solvent mills analyzed was 2.5 cents per dollar of investment. This was equivalent to over 1 cent per bushel of beans. The advantage increased to 5 cents per bushel and over 8 cents per dollar of investment as the size of mill was increased to 200 tons per day in size. Beyond this point, the solvent's advantage per bushel remained relatively stable, though its advantage per dollar of investment continued to increase, particularly up to 400 tons per day.

With increases in the size of mill, investment requirements per bushel of beans declined more rapidly for the solvent process than for screw press, especially up to 400 tons per day. After this point, the requirement declines slowly and at about the same rate for both types of mills. For this reason, the larger the mill size the greater is the advantage of shifting to solvent mills, even though the profit advantage per bushel remains the same. This fact would appear to explain why the rapid shift of the industry from screw-press to solvent mills in recent years has been restricted almost entirely to mills of 200 tons per day in size and over.

I. PROBLEMS AND APPROACHES

GENERAL CHARACTERISTICS OF THE INDUSTRY

The soybean oil mill industry, in terms of production, is the largest of the oilseed-processing industries. In the 1951–52 season, there were approximately 193 mills in the United States with an estimated annual crushing capacity of 310 million bushels.[1] In the 1952–53 season, the industry processed 234 million bushels of soybeans [2] for which farmers received approximately $640 million. Of this total volume, mills located in the 6 main soybean-producing States (Ohio, Indiana, Illinois, Minnesota, Iowa, and Missouri), hereinafter called the Soybean Belt, processed approximately 202 million bushels, or 85 percent. Therefore, the economic conditions characteristic of these States are, in this study, considered as typical of the industry as a whole.

Three general characteristics of the industry gave rise to the central problems of this study.

First, the industry is composed of mills varying widely in size, ranging from under 100 tons of processing capacity per day to well over 1,000 tons (table 1). However, while the capacity of more than 30 percent of the mills operating in the Soybean Belt during the 1952–53 season was 100 tons per day or under, this 30 percent accounted for less than 5 percent of the soybeans processed. Over 90 percent was accounted for by mills processing 200 tons and over per day, and nearly 40 percent by mills processing over 600 tons per day.

Second, at the present time the industry has an excess processing capacity. In the Soybean Belt, the industry had an estimated crushing capacity of nearly 8 million tons of beans (267 million bushels) in the 1952–53 season (table 1), 23 percent of which was excess. (Annual capacity is here considered to be equivalent to the daily rate of operation in the big month maintained for 330 days.) However, mills capable of processing up to 150 tons per day used only 53 percent of their annual capacity, whereas larger mills used 79 percent. In other words, 47 percent of the capacity of small mills was surplus as compared with 21 percent for large mills. Not only was the total amount of beans processed by these small mills substantially less than their capacity, but apparently they found that reselling a quantity of beans equivalent to roughly one-fifth of their unused capacity was more profitable than processing them. In general, large mills resold only a negligible proportion of their soybean purchases.

Third, in general, those familiar with the industry recognize solvent mills as being more efficient than screw-press mills. However, about half the mills of the industry are screw-press mills (table 1), although mills of this type accounted for only 13 percent of the industry's crush in the 1952–53 season as compared with 86 percent by solvent mills.[3] Moreover, no screw-press mill of over approximately 350 tons' daily capacity has operated since 1951, whereas in 1950 mills of this type ranged in size up to 1,000 tons' daily capacity. From these facts arises the question as to the approximate point in the range of mill sizes at which solvent mills become more efficient than screw-press mills.

OBJECTIVES

In line with these general characteristics of the industry, the primary objective of this study is to determine the extent, if any, of possible benefits which might accrue to farmers in the form of

[1] Kromer, George W., and Gilliland, C. B. PROCESSING THE THREE MAJOR OILSEEDS. U. S. Dept. Agr. Mktg. Res. Rpt. 58, 37 pp., illus. 1954.

[2] Kromer, George W. OILSEED PROCESSING TRENDS. U. S. Dept. Agr. Mktg. Activities, June–Aug., pp. 13–17. 1954.

[3] See footnote 2.

TABLE 1.—*Characteristics of soybean oil mills in the 6 major soybean producing States* [1]

Tons processed per day	Type of mill				Average quantity of soybeans processed per mill in big month [2]	Soybeans processed, 1952–53 season		Processing capacity, 1952–53 season		Soybeans shipped from mills, 1952–53 season
	Solvent	Screw press	Combination	Total		Quantity	Proportion	Total estimated [3]	Utilized	
	Number	*Number*	*Number*	*Number*	*Tons*	*Tons*	*Percent*	*Tons*	*Percent*	*Tons*
50 and under	2	11	0	13	1, 064	72, 148	1. 2	152, 119	47	14, 033
51 to 75	0	10	1	11	1, 804	100, 104	1. 6	211, 644	47	20, 975
76 to 100	0	6	0	6	2, 674	88, 834	1. 5	176, 484	50	20, 214
101 to 150	5	2	0	7	3, 436	164, 866	2. 7	264, 550	62	25, 136
151 to 250	4	4	2	10	6, 502	533, 200	8. 8	701, 031	76	36, 644
251 to 350	8	1	3	12	9, 382	930, 907	15. 3	1, 202, 235	77	17, 740
351 to 450	11	0	1	12	11, 940	1, 380, 698	22. 8	1, 576, 193	88	13, 894
451 to 650	4	0	0	4	15, 138	561, 962	9. 3	671, 097	84	[4]
651 to 850	3	0	0	3	22, 842	729, 349	12. 0	765, 094	95	[4]
1,100 and over	3	0	1	4	50, 270	1, 503, 041	24. 8	2, 211, 880	68	[4]
All	[5] 41	[6] 42	8	[7] 91	8, 839	[7] 6,070, 116	100. 0	7, 932, 327	77	234, 511

[1] Illinois, Indiana, Iowa, Minnesota, Missouri, and Ohio.

[2] Based on quantity of soybeans processed in the big month of the 3-year period, 1950–51 through 1952–53 seasons.

[3] Based on daily rate of operation in big month maintained for 330 days.

[4] Not shown to avoid disclosure of individual companies' operation.

[5] Includes 1 solvent mill processing under 150 tons per day included in total but omitted in size analysis.

[6] Includes 8 screw-press mills processing under 150 tons per day included in total but omitted in size analysis.

[7] Includes 9 mills under 150 tons per day processing a total of 5,007 tons for the 3-year period and for which no size distribution was made as their annual crush did not equal 1 month's crush as measured by big month.

Compiled from special surveys made by the Bureau of the Census in cooperation with the U. S. Department of Agriculture.

higher prices for their soybeans, from industrywide increase in sizes of soybean oil mills.

Achievement of this objective required analysis of the way in which change in the size of mill is related to corresponding variation in total cost and total revenue as means of comparing the mills' net revenues per bushel of beans and per dollar of investment. Gains, if any, in net revenue per bushel of beans will show the increase in production efficiency which, under given price relationships, would accrue to society from industrywide adoption of more efficient size mills. The net revenues of different sizes of mills when expressed as profits per dollar of investment will show which sizes of mills are more advantageous from the standpoint of the owner. Profit per dollar of investment when converted to profit per bushel of beans will show the extent to which more efficient mills could bid up the price of beans if they should use their profit differential for this purpose.

A secondary purpose of the study is to determine the approximate point in the scale of operations at which solvent mills come to earn more net revenue than screw-press mills. This question merits attention because of the large number of screw-press mills still operating, and which are under 200 tons per day in size.[4]

GUIDING ASSUMPTIONS

A number of guiding assumptions were accepted as fundamental throughout the study in order to place all mills on a comparable basis.

First, cost-price relationships of the 1952–53 season were assumed for all mills, this season being the latest period for which requisite conditions and data were available.

Second, all mills in the study were assumed to process soybeans into their first products only—crude oil and meal. In other words, this study does not deal with vertically integrated mills, processing soybeans into such secondary products as refined oil and mixed feed. In many ways integrated mills are able to achieve economies which are not possible for nonintegrated mills processing the same volume of beans daily and annually. Therefore, it is recognized that findings for mills in this study may not apply to integrated mills of the industry, but the findings are the closest approximation to the economies in the

[4] In line with the recommendations of the Secretary of Agriculture's Oilseeds and Peanut Research and Marketing Advisory Committee, this study was initiated in 1951. At that time, approximately 40 percent of the soybean crop was processed by screw-press mills. The contemplated goals of the study included a determination of (1) which type of process was more economical throughout the entire size range of mills, and (2) how a relatively complete changeover to the solvent process would affect the total supply and price of oil and the total number and sizes of mills in the industry as well as gross returns to farmers for their soybeans. Upon the close of the Korean conflict, the mills shifted so rapidly to the solvent process that by the 1952–53 season solvent mills accounted for approximately 86 percent of all beans processed. In view of this rapid change in the structure of the industry, the aims of the study were revised to include only those specified.

TABLE 2.—*Processing capacities of soybean oil mills selected for study*

Mill	Daily capacity per 24 hours at normal rate [1]	Annual capacity at 330 days per year	
Solvent:	*Tons*	*Tons*	*Bushels*
Plant 1	25	8, 250	275, 000
Plant 2	50	16, 500	550, 000
Plant 3	100	33, 000	1, 100, 000
Plant 4	150	49, 500	1, 650, 000
Plant 5	200	66, 000	2, 200, 000
Plant 6	300	99, 000	3, 300, 000
Plant 7	400	132, 000	4, 400, 000
Plant 8	500	165, 000	5, 500, 000
Plant 9	600	198, 000	6, 600, 000
Plant 10	800	264, 000	8, 800, 000
Plant 11	1, 000	330, 000	11, 000, 000
Screw-press:			
1 press	25	8, 250	275, 000
2 press	50	16, 500	550, 000
4 press	100	33, 000	1, 100, 000
6 press	150	49, 500	1, 650, 000
8 press	200	66, 000	2, 200, 000
12 press	300	99, 000	3, 300, 000
16 press	400	132, 000	4, 400, 400
20 press	500	165, 000	5, 500, 000
24 press	600	198, 000	6, 600, 000
32 press	800	264, 000	8, 800, 000

[1] In general it is considered by the industry that such mills will permit a maximum operating rate of 125 percent of the normal and can be varied downward indefinitely.

actual milling of soybeans which can be achieved from available information.

Third, as a means of placing different mills on a comparable basis, particularly with respect to investment requirements and fixed cost, new mills were assumed. These mills, the sizes of which are specified in table 2, were developed through engineer's drawings and cost calculations for component elements of the structures and operations. The layouts of these mills were checked at various points with those of actual mills. They were not designed to be perfect mills, but realistic models or patterns of well-constructed, well-operated mills.

The engineering work of the study involved two principal phases. One was the estimation of investment requirements for new mills of different sizes and types. How this was done is described in the appendix.[5] The second phase of the engineering work was the estimation of processing requirements such as man-hours, kilowatt-hours, pounds of steam, and gallons of fuel oil. These requirements were estimated on either a per ton or per bushel of beans basis, depending in each case on the custom of the industry. This phase of the study is treated in section III.

Fourth, all mills were assumed to operate at the normal daily processing rates for which they were designed. They were also assumed to operate for a 12-month or 330 24-hour working days per year.

Finally, it was assumed that all mills were operated under average conditions with respect to costs per unit of input (e. g., wages, power, fuel oil, meal bags, property taxes, and the like), transportation costs of soybeans, the proportions of bulk and bagged meal produced, and f. o. b. mill returns for oil and meal.

II. YIELDS OF SOYBEAN PRODUCTS

Processing soybeans yields two products, oil and meal. The yield of meal by weight is about four times that of oil, the amounts varying with the composition of the soybeans as well as with the method of processing. The oil, protein, and moisture content of the beans, and also the foreign material included with the beans, determine the amounts of oil and meal obtained by different methods of processing. The average yields for the 2-year period, 1951 and 1952, as reported by the Bureau of Census, were used in this study and are shown in table 3.

III. PRODUCTIVE SERVICES

This chapter is mainly concerned with (1) the rates at which productive services (e. g., capital, labor, power, materials, supplies, etc.) are used in soybean processing, and (2) the cost rates of each unit of service (e. g., wages per man-hour, price of fuel oil per gallon). In case of major services (e. g., the physical plant, labor, power) the variation in cost per bushel of soybeans with size of mill is developed.

Productive services were grouped into three main categories: (1) Plant, (2) procurement of

TABLE 3.—*Yield of products per bushel of soybeans processed by solvent and screw-press methods, 1951 and 1952 seasons*

Season beginning October—	Solvent		Screwpress	
	Oil	Meal	Oil	Meal
	Pounds	*Pounds*	*Pounds*	*Pounds*
1951	10. 5	46. 4	8. 5	49. 3
1952	11. 1	46. 9	9. 2	50. 4
Average [1]	11. 0	47. 0	9. 0	50. 0

[1] Average of yearly yields weighted by soybeans processed.

Special surveys by the Bureau of the Census in cooperation with the U. S. Department of Agriculture.

[5] In general, investment requirements would be approximately the same for mills in both the Soybean Belt and elsewhere as layouts for mills of the same type and size would be essentially the same in any region. However, soybean unloading facilities would differ considerably for mills in the Soybean Belt and southern mills because railroad car deliveries are usually greater than truck deliveries in the Soybean Belt, whereas most beans are delivered to mills by truck in the South. This difference was taken account of in the designs developed and is described in the bean storage section (pp. 43–50).

beans, and (3) operating. Plant services represent costs which are incurred irrespective of whether the mill is used. Operating services represent processing costs which are incurred only when the plant is actually running and arise only after soybeans are delivered to the mill.

It was realized that costs could be either cumulated separately for each of the specified mills or developed mathematically in such a way that they would vary continuously with size of mill. The first method was chosen in this study because it appeared to afford more explanation of the actual process of developing costs, even though it resulted in some minor irregularities in the variation of cost with size of mill.

PLANT SERVICES

In this study, depreciation, interest, taxes, and insurance are called plant costs. (Repairs were treated as an operating cost.) All mills in the study were placed on a comparable basis with respect to these costs through designing property layouts for new mills and estimating their investments, department by department. The manner in which this was done is described in detail in the appendix, "Plant Designs and Investment Requirements." Costs of using the plants were then calculated by applying to these investments, as shown in tables 82, 83, and 85 of the appendix, the depreciation, interest, insurance, and property tax rates which are described in the following paragraphs.

TABLE 4.—*Depreciation rates used for soybean oil mills, by type of asset*

Type of asset	Length of useful life	Annual rate
	Years	*Percent*
Soybean storage silos	50	2.0
Fire pump house	50	2.0
Steel frame buildings	40	2.5
All tanks	40	2.5
Lockers	40	2.5
Post indicator valves	40	2.5
Water main	40	2.5
Facilities for storage and grinding of soybean screenings	[1] 28	3.6
Solvent extraction building and equipment	25	4.0
Machinery and equipment [2]	25	4.0
Miscellaneous service facilities	20	5.0
Office and laboratory equipment	[3] 15	6.7
Minor fire protection equipment	10	10.0
Trucks and automobiles	6	16.7

[1] Estimated composite rate based on 40 years of useful life for storage bins and 25 years for machinery and equipment.

[2] Includes all machinery and equipment not shown separately.

[3] Composite rate for office equipment based on 20 years for office furniture and 10 years for other items.

Based on data made available by the Bureau of Internal Revenue.

TABLE 5.—*Estimated urban real estate tax rates per $100 of full value for 5 major soybean States, 1952*

State	Rural tax rate [1]	Ratio of urban to rural tax rate [2]	Urban tax rate [3]
	Dollars	*Percent*	*Dollars*
Illinois	1.08	140	1.51
Indiana	.82	182	1.49
Iowa	1.11	176	1.95
Minnesota	1.43	160	2.29
Ohio	.73	148	1.08
Average [4]	1.02	154	1.57

[1] Data from table 26, Agricultural Finance Review, vol. 16, Nov. 1953, U. S. Dept. Agr.

[2] Based on data for latest available years from State tax reports.

[3] Rural tax rate times ratio of urban to rural tax rate.

[4] Weighted by average soybeans crushed in 1949–51 crop-years in each State.

DEPRECIATION RATES

As shown in table 4, eight different depreciation rates for correspondingly different types of assets were used, depending on the estimated length of the useful life of the type of structure and equipment or facility involved. These rates are similar to those used by the Bureau of Internal Revenue for tax evaluation purposes.

INTEREST

A charge of 4 percent per annum was made on the original investment in mills. Capital has a cost regardless of its ownership. In line with this fact, interest was allowed on the original investment irrespective of whether an operator might use his own or borrowed funds. Four percent is the legal interest rate of the Bank of Cooperatives, and appears reasonable for purposes of this study, though it was recognized that somewhat lower rates might be possible for some operators.

TAXES

Property taxes were calculated by applying a rate of $1.57 per $100 of original plant investment. This figure is the estimated average tax charge on urban property for the States shown in table 5. Data for special assessments were not available.

INSURANCE

The fire protection characteristics of the mills in this study are described on pages 84, 87–91. In terms of these characteristics, mills are eligible for the lowest cost insurance available, subject to final inspection by the insurer for actual compliance with the above standards. Such insurance is available under a single policy blanketing

TABLE 6.—*Cost of plant services per bushel of soybeans processed, by type and size of mill, 1952–53 season*

Type and size of mill	In production of both bagged and bulk meal					In production of bulk meal only				
	Depreciation	Interest	Taxes	Insurance	Total	Depreciation	Interest	Taxes	Insurance	Total
Tons per day										
Solvent:	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
25	8. 058	8. 872	3. 439	0. 396	20. 765	7. 867	8. 896	3. 464	0. 397	20. 624
50	4. 882	5. 499	2. 132	. 246	12. 759	4. 751	5. 465	2. 126	. 244	12. 586
100	3. 397	3. 948	1. 526	. 177	9. 048	3. 368	3. 979	1. 546	. 178	9. 071
150	3. 062	3. 640	1. 410	. 163	8. 275	3. 001	3. 558	1. 383	. 159	8. 101
200	2. 801	3. 372	1. 306	. 151	7. 630	2. 756	3. 310	1. 286	. 148	7. 500
300	2. 393	2. 867	1. 108	. 128	6. 496	2. 348	2. 806	1. 088	. 126	6. 368
400	2. 128	2. 573	. 995	. 115	5. 811	2. 102	2. 539	. 984	. 114	5. 739
500	2. 078	2. 565	. 993	. 115	5. 751	2. 019	2. 498	. 969	. 112	5. 598
600	2. 255	2. 795	1. 084	. 125	6. 259	2. 235	2. 766	1. 075	. 124	6. 200
800	1. 994	2. 500	. 969	. 112	5. 575	1. 979	2. 475	. 963	. 111	5. 528
1,000	1. 801	2. 273	. 881	. 102	5. 057	1. 788	2. 252	. 876	. 101	5. 017
Screw-press:										
25	5. 684	6. 320	2. 446	. 283	14. 733	5. 470	6. 307	2. 456	. 282	14. 515
50	3. 529	4. 081	1. 578	. 182	9. 370	3. 385	4. 026	1. 565	. 180	9. 156
100	2. 621	3. 162	1. 221	. 142	7. 146	2. 580	3. 175	1. 234	. 142	7. 131
150	2. 336	3. 161	1. 224	. 141	6. 862	2. 273	3. 075	1. 195	. 137	6. 680
200	2. 421	3. 003	1. 163	. 134	6. 721	2. 374	2. 938	1. 142	. 131	6. 585
300	2. 122	2. 602	1. 006	. 116	5. 846	2. 075	2. 538	. 985	. 114	5. 712
400	1. 912	2. 360	. 913	. 106	5. 291	1. 885	2. 323	. 901	. 104	5. 213
500	1. 925	2. 410	. 933	. 108	5. 376	1. 864	2. 342	. 910	. 105	5. 221
600	2. 097	2. 639	1. 024	. 118	5. 878	2. 076	2. 608	1. 015	. 117	5. 816
800	1. 889	2. 399	. 931	. 108	5. 327	1. 873	2. 373	. 924	. 106	5. 276

all buildings and their contents (soybeans, soybean meal, and oil in storage), and including all property within plant yards having insurable values. The hazards covered are fire, wind, cyclone, lightning, smoke and water damage, sprinkler leakage damage, falling aircraft, vehicle, riot, civil commotion, vandalism, malicious mischief, and explosion. Such protection is available for full insurable value of buildings and their contents at 15 cents per $100 of insurance.

Such blanket insurance is also available on a coinsurance basis, usually for 80 or 90 percent of their insurable value. A mill having an 80-percent coinsurance policy would be paid only 80 percent of the loss in case of damage. In other words, the mill itself would carry 20 percent of its own insurance risk. This report used 100-percent coverage.

As all mills in this study would be new, their insurable value was assumed to be equivalent to their actual cost of construction. To allow a margin for structural corrections that might be needed in meeting final inspection requirements, this study used 18 cents per $100 of extended insurance instead of the smaller figure of 15 cents mentioned above.

TOTAL PLANT COSTS PER BUSHEL

Cost of individual plant services are summarized on a per bushel of beans basis in table 6. Investment requirements vary for different types and sizes of mills according to the proportion of the different forms (bagged and bulk) of meal produced.

In recent years, bulk meal has become the major form of meal produced, the ratio of bulk to bagged meal being about 3 to 1. Small mills, particularly those selling most of their meal locally, produce most of their meal in bagged form whereas larger mills produce mostly bulk meal. Table 7 gives the percentages of the forms of meal produced by size of mill. These percentages were assumed to be representative of the industry. Since investment costs for meal storage and shipping depend

TABLE 7.—*Percentages of bagged and bulk soybean meal production in soybean oil mills, by size of mill, 1952–53 season* [1]

Size of mill	Bagged	Bulk
Tons per day	*Percent*	*Percent*
25	100	0
50	66	34
100	44	56
150	36	64
200	32	68
300	28	72
400	27	73
500	25	75
600	25	75
800	24	76
1,000	23	77

[1] Based on analysis of data furnished by National Soybean Processors Association.

TABLE 8.—*Average price per bushel of soybeans received by farmers in the 6 major soybean producing States, 1951, 1952, and 1953 crops* [1]

State	1951–52	1952–53	1953–54
	Dollars	*Dollars*	*Dollars*
Illinois	2. 77	2. 78	2. 79
Indiana	2. 73	2. 72	2. 67
Iowa	2. 74	2. 69	2. 91
Minnesota	2. 68	2. 62	2. 75
Missouri	2. 69	2. 71	2. 53
Ohio	2. 77	2. 71	2. 80
Average	2. 74	2. 73	2. 75

[1] Total soybeans sold in these States represented 83, 82, and 86 percent of the total amounts sold in the United States for the crops of 1951, 1952, and 1953, respectively.

Farm Production, Farm Disposition and Value of Principal Crops, 1951–52 and 1952–53, Field and Seed Crops, Farm Production, Farm Disposition, Value, 1953–54. U. S. Dept. Agr., Crop Reporting Board.

on the amounts of the forms of meal produced, such costs were estimated assuming both (1) the usual proportions of bagged and bulk meal produced (table 7), and (2) only bulk meal production. Estimates were made on the basis of the second assumption in order to analyze the effect of size of mill on costs if only one form of meal is produced.

PROCUREMENT OF SOYBEANS

As used in this study, procurement costs included (1) the price of beans received by farmers (2) charges for handling beans by country elevators and intermediaries other than country elevators and (3) transportation costs on soybeans delivered to mill. These combined charges equal cost of beans delivered to the mill.

SOYBEAN PRICES RECEIVED BY FARMERS

The study used the average soybean price of $2.73 per bushel received by farmers for the 1952–53 crop of soybeans in the 6 central soybean States, as shown in table 8.

COUNTRY ELEVATOR AND OTHER INTERMEDIARY HANDLING CHARGES

No charges for handling were assumed for beans acquired direct from farmers. A charge of 6 cents per bushel was allowed for all beans acquired from country elevators. This figure was based on reports in 1953 of 9 mills in the 4 central soybean States, ranging in size from 100 to over 1,000 tons of crushing capacity per day.

Based on these same reports, an additional 2 cents per bushel was allowed for all beans acquired through interior carlot dealers or commission firms. The principal function of these intermediaries is to help bring together soybean operators and country elevators, guarantee contracts between them, and facilitate payment. Sometimes operators may build up their own seed-buying force. But it was assumed that the cost of seed-buying services would be approximately the same in either case.

The proportion of beans acquired from farmers, country elevators, interior carlot dealers, and commission firms varies widely with different size mills. Usually large mills get most of their beans through interior carlot dealers or commission firms, a minor portion from country elevators, and virtually none direct from farmers, whereas the reverse is true of small mills.

Table 9 shows the relationship between sizes of mills and the proportions of soybeans acquired from different suppliers. The relationship was based on the judgment of a number of experienced operators.

TRANSPORTATION CHARGES

The transportation charges used in this study are shown in table 10. The charges shown reflect in-transit freight privileges on the meal portion of beans processed in transit. They also reflect the proportions of beans delivered by truck.

TOTAL ACQUISITION COST AND DELIVERED COST PER BUSHEL OF BEANS

Total acquisition cost and the cost of beans delivered at the mill are shown in table 10.

TABLE 9.—*Estimated soybean handling charges paid by soybean oil mills, by size of mill, 1952–53 season*

Size of mill	Soybeans processed annually	Proportion of soybeans acquired from [1]—			Average handling charges per bushel [3]
		Farmers	Country elevators	Other intermediaries [2]	
Tons per day	*Bushels*	*Percent*	*Percent*	*Percent*	*Cents*
25	275, 000	100	0	0	0. 0
50	550, 000	75	25	0	1. 5
100	1, 100, 000	25	50	25	5. 0
150	1, 650, 000	10	35	55	6. 5
200	2, 200, 000	10	35	55	6. 5
300	3, 300, 000	5	25	70	7. 1
400	4, 400, 000	5	25	70	7. 1
500	5, 500, 000	0	10	90	7. 8
600	6, 600, 000	0	10	90	7. 8
800	8, 800, 000	0	10	90	7. 8
1,000	11, 000, 000	0	10	90	7. 8

[1] Based on estimates of operators.

[2] Include interior carlot dealers and commission firms.

[3] Proportion of soybeans acquired from farmers, country elevators, and intermediaries weighted by handling charges per bushel of 6 and 8 cents for country elevators and intermediaries, respectively. No charges incurred on beans acquired directly from farmers. These handling charges are averages based on interviews in 1954 with 9 mill operators located in Illinois, Indiana, Iowa, and Ohio.

TABLE 10.—*Estimated acquisition cost and total delivered cost per bushel of soybeans at soybean oil mills, by size of mill, 1952–53 season*

Size of mill	Soybeans processed annually	Acquisition cost			Delivered cost [3]
		Payments to country elevators and other intermediary dealers [1]	Transportation of soybeans to mill [2]	Total	
Tons per day	*1,000 bushels*	*Cents*	*Cents*	*Cents*	*Dollars*
25	275	0. 0	1. 9	1. 9	2. 749
50	550	1. 5	1. 9	3. 4	2. 764
100	1, 100	5. 0	1. 9	6. 9	2. 799
150	1, 650	6. 5	2. 7	9. 2	2. 822
200	2, 200	6. 5	2. 7	9. 2	2. 822
300	3, 300	7. 1	3. 2	10. 3	2. 833
400	4, 400	7. 1	3. 2	10. 3	2. 833
500	5, 500	7. 8	3. 3	11. 1	2. 841
600	6, 600	7. 8	3. 3	11. 1	2. 841
800	8, 800	7. 8	3. 3	11. 1	2. 841
1,000	11, 000	7. 8	3. 3	11. 1	2. 841

[1] From table 9.

[2] Based on analysis of transportation cost data for the 1951 and 1952 seasons for mills operating in the 6 main soybean States. Data made available by the National Soybean Processors Association.

[3] Total acquisition cost plus average price of $2.73 (table 8) received by farmers for beans.

OPERATING SERVICES

Operating services were grouped into 10 categories: Labor, salaries and general administrative expense, welfare risks, maintenance and repairs, utilities, supplies, laboratory services, insurance (on soybeans and soybean products), product selling, and interest on working capital.

LABOR

Labor was handled in three stages: Man-hour requirements, wage rates, and labor cost per bushel of soybeans.

All man-hour requirements were estimated in detail by type of operation (such as bean unloading) and by type and size of mill. The estimates were submitted to soybean oil mill operators and other qualified persons for checking. A considerable amount of data from operating mills was available to those who made the detailed estimates.

Man-hour Requirements

Man-hour requirements were broken down into seven main categories: (1) Bean unloading, (2) bean storage, (3) bean preparation, oil extraction, and meal processing, (4) meal bagging, (5) meal loading, (6) maintenance, and (7) miscellaneous.

BEAN UNLOADING. Man-hours for unloading soybeans were estimated on the basis of (1) the number and type of mechanical bean unloaders per mill, (2) the normal unloading crew per unloader, and (3) the average unloading rate per unloader.

Three types of equipment were provided for unloading soybeans, the type depending upon the size of the mill: (1) truck dumpers, (2) power shovel boxcar unloaders, and (3) boxcar dumpers. The number and type of unloaders for each size mill are shown in table 45 in the appendix.

UNLOADING TRUCKS BY DUMPER. For unloading beans by 1-truck dumper, it was estimated that a 3-man operating crew was needed: 1 sampler, 1 weigher and grader, 1 dumper operator. A part-time distributing belt-tripper operator would also be required, but the part-time worker was considered a part of the storage operating force.

For 2-truck dumpers the estimated crew of 5 full-time men and 1 half-time man included: 1 sampler, 1 weigher, 1 grader (or 2 weigher-graders), 2 dumper operators, and a half-time distributing belt tripper operator.

Using an unloading rate of 3,000 bushels per hour per dumper, the man-hour requirements per ton of soybeans unloaded were: 0.035 man-hour per ton for 1 dumper

$$\left(\frac{3 \text{ men} \times 2{,}000 \text{ lbs.}}{3{,}000 \text{ bu. per hr.} \times 57 \text{ lbs.}}\right).$$

and 0.032 man-hour per ton for 2 dumpers

$$\left(\frac{5.5 \text{ men} \times 2{,}000 \text{ lbs.}}{6{,}000 \text{ bu. per hr.} \times 57 \text{ lbs.}}\right).$$

A figure of 0.034 man-hour per ton was used for either 1- or 2-truck dumpers.

TABLE 11.—*Labor requirements for unloading soybeans in soybean oil mills, by size of mill*

Size of mill	Soybeans received [1]		Labor required per ton for unloading soybeans received [2]		
	By truck	By rail	By truck	By rail	Total
Tons per day	*Percent*	*Percent*	*Man-hours*	*Man-hours*	*Man-hours*
25	90	10	0. 034	0. 060	0. 037
50	75	25	. 034	. 060	. 041
100	50	50	. 034	. 060	. 047
150	40	60	. 034	. 060	. 050
200	35	65	. 034	. 060	. 051
300	35	65	. 034	. 060	. 051
400	30	70	. 034	. 060	. 052
500	25	75	. 034	. 060	. 054
600	20	80	. 034	. 017	. 020
800	15	85	. 034	. 017	. 020
1,000	10	90	. 034	. 017	. 019

[1] Based on judgments of persons familiar with soybean operations.

[2] Based on type of unloaders used (table 45) and labor requirements per unloader (p. 9). Total labor is equivalent to man-hours required for unloading by truck and rail, weighted by percentages of soybeans delivered by each.

Unloading Boxcars by Power Shovel. For unloading beans from railroad boxcars by 2 double power shovels with either a hopper scale in the workhouse to weigh each carload, or railroad track scale over each unloading pit, a 6-man crew was estimated: 4 shovel operators for the 2 sets of shovels, 1 relief shovel operator who would also help move cars and handle grain doors, and 1 weighmaster.

The average unloading rate per double shovel unloader is one 50-ton car per hour; hence the labor requirement per ton of beans unloaded for a 2 double shovel setup is 0.06 man-hour per ton

$$\left(\frac{6 \text{ men}}{2 \text{ double shovels} \times 50 \text{ tons per hour}}\right)$$

For unloading with 1 or 3 double power shovels, the labor requirements would be about proportionate to that for 2 shovels and the unloading man-hours per ton of beans would be the same as for 2 shovels.

Unloading Boxcars by Dumper. A 5-man crew was estimated for unloading beans from boxcars by a tilting car dumper: 1 dumper operator, 1 dumper operator helper, 1 car spotter, 1 hopper scale weighmaster, and 1 distributing belt-tripper operator. Grain doors were assumed to be returned to the cars after unloading.

The average unloading rate per car dumper is about 6 to 8 cars per hour. As the net contents of cars may vary from about 40 to 50 tons, a conservative labor requirement per ton of beans unloaded was estimated as 0.017 man-hour

$$\left(\frac{5 \text{ men}}{6 \text{ cars} \times 50 \text{ tons}}\right)$$

Bean Unloading Labor and Size of Mill. As all mills would receive some beans by truck, all were equipped with a truck dumper. To receive rail-delivered beans, mills through 500 tons per day were provided with power shovels, while larger mills were provided with boxcar dumpers.

Unloading labor per ton of beans varied somewhat with size of mill because of corresponding variation in (1) types of unloaders, and (2) percentages of beans delivered by truck and rail.

Taking both these variables into account, table 11 shows the number of man-hours required per ton of soybeans unloaded by size of mill.

Soybean Storage. In conformity with industry practices (p. 42), sufficient storage facilities were provided to enable 400-ton-per-day mills and under to store enough beans for approximately 80 days of operation and larger mills enough for 100 days. This difference is not enough to appreciably disturb the comparative economies of different size mills.

Table 12 shows the labor requirements for these amounts of storage facilities in terms of man-hours per ton of beans.

These figures were checked with the judgment of experienced operators and were found to be reasonable under normal conditions. However, they have only limited accuracy in individual cases, as the number of men for a given total storage capacity would vary from mill to mill, depending upon many factors such as physical layout of the elevator department, capacities of equipment, and local operating practices.

Oil Extraction and Meal Processing. The number of man-hours per ton of beans, allowed for oil extraction (including bean preparation) and meal processing, are shown in table 13 for different size solvent mills. The same relationship is shown in table 14 for screw-press mills.

For reasons stated (p. 27), two calculations were

Table 12.—*Normal labor requirements for storing soybeans, by size of mill*

Size of mill	Storage facilities			Men required per 40-hour week					Man-hours per ton of beans [3]
	Storage capacity provided [1]	Dryers [2]	Cleaners [2]	Storage operator	Dryer and cleaner operator	Lubrication and miscellaneous	Clerk	Total	
Tons per day	*1,000 bu.*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
25	70	1	([4])	1				1	0. 229
50	140	1	([4])	1				1	. 114
100	334	1	([4])	1				1	. 057
150	442	1	1	2				2	. 076
200	575	1	1	2				2	. 057
300	791	1	1	2				2	. 038
400	1, 115	1	1	3				3	. 043
500	1, 763	1	1	3	1			4	. 046
600	2, 132	2	1	4	1	1		6	. 057
800	2, 840	2	2	4	1	1		6	. 043
1,000	3, 488	2	2	4	2	1	1	8	. 046

[1] From table 43.
[2] From table 45.
[3] Number men times 40 hours per week / Tons per day times 7 days per week
[4] Cleaners provided in processing department.
Data from Texas Engineering Experiment Station.

TABLE 13.—*Labor requirements for flake preparation, oil extraction, and meal processing departments in solvent soybean oil mills*

Size of mill	Operators required for each position [1]												Man-hours per ton of beans [12]
	Flake preparation		Extraction			Meal processing [7]	Helping in preparation and meal processing [8]	Relief [9]	Lubrication and oil loading [10]	Boiler	Supervision (foreman) [11]	Total	
	No. 1 [2]	No. 2 [3]	No. 1 [4]	No. 2 [5]	Helper [6]								
Tons per day	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
25	4	------	4	------	-------	-------	[8] 4	1	----------	------	4	[13] 17	[13] 3.886
50	4	------	4	------	-------	-------	[8] 3	1	----------	------	4	[13] 16	[13] 1. 829
100	4	------	4	------	-------	4	[8] 5	1	1	------	4	[13] 23	[13] 1. 314
150	4	------	4	------	-------	4	---------	1	1	------	4	18	. 686
200	4	------	4	------	-------	4	---------	1	2	4	4	23	. 657
300	4	------	4	4	-------	4	---------	1	2	4	4	27	. 514
400	4	------	4	4	1	4	4	2	2	4	4	33	. 471
500	4	------	4	4	1	4	4	2	3	4	4	34	. 389
600	4	4	4	4	1	4	4	2	3	4	4	38	. 362
800	4	4	4	4	2	4	4	2	4	4	4	40	. 286
1,000	4	4	4	4	2	4	4	2	4	4	4	40	. 229

[1] Each man works a 40-hour week. Requirements are estimated under the assumption that both bagged and bulk meal are produced. When only bulk meal is produced, the requirements differ for small mills as noted.

[2] Operates machinery to fill bean tank; watches scale and regulates material flows; takes samples and tests bean moisture, crack, conditioned bean moisture, flake thickness; adjusts cracking rolls, conditioner, flaking rolls; keeps plant clean; operates bean cleaning machinery and steam boiler in small mills.

[3] Assumes part of duties of preparation operator No. 1 as two parallel flows of material through process is assumed to begin with 600 tons per day.

[4] Operates 1 or 2 extractors, 1 or more meal desolventizing and toasting systems, meal coolers, 1 or 2 oil desolventizing systems, vapor recovery system, solvent-water separation; works with extraction operator No. 2.

[5] Divides duties of extraction operator No. 1.

[6] Sweeps, cleans filters, washes filter cloths, and works wherever needed.

[7] Watches machinery and material flows through meal screening and grinding operations and conveying to storage tanks; takes samples and tests screen analysis and moisture in meal; helps roll operators; keeps plant clean, operates facilities for storage, grinding, and addition of screenings to meal.

[8] In small mills (100 tons per day and under), sacks meal as it is produced and stores it in warehouse or loads it for shipping; but is not required if only bulk meal is produced; in large mills, helps other operators.

[9] Relieves operators and assists where needed to allow continuous operation with a 40-hour week.

[10] Lubricates all machinery, unloads solvent to storage, loads oil shipped, makes small repairs; serves as extra operator.

[11] Works between the preparation and extraction departments, since the extraction department is isolated from the other buildings.

[12] Equal to: Number of men times 40 hours per week divided by the product of tons per day and 7 days per week.

[13] When only bulk meal is produced, the total number of men is reduced by the number of helpers in the preparation and meal processing departments and also reduced is the man-hour requirements per ton of beans.

Data from Texas Engineering Experiment Station.

made: One on the assumption that the mills produce bagged and bulk meal in the proportions shown in table 7; the other on the assumption that all mills produce bulk meal only. Both calculations were reached through breaking down the entire preparation, oil extraction, and meal-processing operations into the main types of jobs involved and estimating the number of men required per 40-hour week to maintain continuous operation. It should be observed, however, that the total labor for each mill is subject to less error than the individual components.

Labor requirements provided for solvent mills of approximately 25 to 100 tons per day in this study may be somewhat greater than those of actual mills of this size, owing to a difference in design. In actual solvent mills of this size, the meal room and extraction room are often separated only by a fire wall. In this study, however, all solvent mills were designed so that the extraction department was located in a building approximately 100 feet from the other buildings. This arrangement was made in the interest of safety, but it required the addition of a foreman who would divide his time between the flake preparation and extraction operations. With this exception, checks indicated that the labor provided for mills in this study was approximately the same as that of well-operated actual mills. Thus the labor for 16 actual screw-press mills ranging from 25 to 150 tons per day in size was in line with that of this study. The same was true of a check on the 200-ton solvent mill with 2 different operators. The data in tables 13 and 14 were reviewed critically by large firms operating several mills and were judged to be most reliable.

BAGGING MEAL, HANDLING MEAL BAGS, AND LOADING BAGGED MEAL. During an 8-hour shift,

an average bagging rate of 5 bags per minute per bagging scale may be maintained for 7 hours. At this rate, approximately 105 tons of meal can be bagged per shift (7 hours×5 bags×60 minutes×100 pounds per bag÷2,000 pounds per ton). Conveying equipment was provided to carry bagged meal from the sewing machine to a railroad car or auto truck for piling. The labor crew estimated to bag and load this production consisted of 4 men: 1 man bagging, 1 man sewing, 1 man receiving bags from the conveyor and stacking them in car or truck, and 1 man to inspect the car, prepare it for loading, spot and move full and empty cars, close cars, and relieve other operators. With this 4-man crew bagging 105 tons of meal per 8 hours, the labor requirement for meal bagging is 0.3 man-hour per ton of meal bagged $\left(\frac{4 \text{ men} \times 8 \text{ hours}}{105 \text{ tons}}\right)$. Large mills were provided with 2 bagging scales, but the labor requirement per ton is the same as for one scale, since the crew consists of 8 instead of 4 men.

The labor requirements for meal bagging per ton of beans processed for different-size mills given in table 15 were estimated by using the average meal yields (table 3) and normal proportions of bagged meal produced (table 7).

Loading Bulk Meal. It was assumed that all bulk meal would be loaded into railroad cars. This operation includes inspection of cars and cleaning if necessary, installing grain doors, car spotting and taking tare weight if spotted on scale, meal loading, weighing if loaded on scale, and moving cars away to allow spotting of new cars.

Two men operating a belt thrower can load approximately 1 car per hour with 30 to 40 tons of meal. Using an average of 35 tons per car, the man-hour requirement per ton is 0.057, which was rounded to 0.06 man-hour. At 0.06 man-hour per ton, the average loading rate with one belt thrower is 32.5 tons per hour, which is conservative.

Assuming the average relationship of bulk and bagged meal by size of mill, table 15 shows the bulk meal loading labor for the mills used in this study.

Miscellaneous Labor. Such labor as janitors, storeroom clerks, watchmen, and truck drivers was grouped into a miscellaneous category. For mills of over 100 tons per day in size, this labor was estimated as being equivalent to 10 percent of the combined labor for the elevator department (excluding bean unloading), and the processing department as shown in tables 16 and 17. For smaller mills it was assumed that mis-

Table 14.—*Labor requirements for oil extraction and meal processing departments in screw-press soybean oil mills*

Size of mill	Operators required for each position [1]								Man-hours per ton of beans [8]
	Screw press		Dryer and meal processing [4]	Helping [5]	Relief [6]	Lubrication and oil loading [7]	Boiler	Total	
	No. 1 [2]	No. 2 [3]							
Tons per day	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
25	4	----	----	4	1	----	----	9	2. 057
50	4	----	----	4	1	----	----	9	1. 029
100	4	----	4	[9] 6	1	----	----	[9] 15	[9]. 857
150	4	----	4	1	1	1	----	11	. 419
200	4	----	4	2	1	1	4	16	. 457
300	4	----	4	4	1	2	4	19	. 362
400	4	4	4	2	1	2	4	21	. 300
500	4	4	4	3	1	2	4	22	. 251
600	4	4	4	3	1	3	4	23	. 219
800	4	4	4	4	1	3	4	24	. 171

[1] Each man works a 40-hour week. Requirements are estimated under the assumption that both bagged and bulk meal are produced. When only bulk meal is produced the requirements differ for the 100 ton-per-day mill only, as noted.

[2] Operates machinery to fill bean tank; watches scale and regulates material flows; takes samples and tests whole bean and dried bean moisture and fineness of crack; adjusts cracking rolls, dryers, screw-presses; cleans filter press; and places oil in storage. In small mills (100 tons per day and under) also operates bean cleaning machinery.

[3] Assists screw-press operator No. 1.

[4] Operates dryers, cake cooling and grinding equipment, and meal conveying and elevating machinery to storage. In small mills also assists screw-press operator, lubricates machinery, and operates steam boiler.

[5] In small mills, sacks meal as it is produced and loads meal into cars. In larger mills, helps other operators.

[6] Relieves operators to allow continuous operation with 40-hour week and works at oil loading and miscellaneous other jobs.

[7] Lubricates machinery, loads oil shipped, performs small maintenance jobs, and serves as extra operator.

[8] Equal to: Number of men times 40 hours per week divided by the product of tons per day and 7 days per week.

[9] If bulk meal only is produced, only 1 operator's helper is needed; therefore, total number of men is reduced by 5 and the man-hour requirements per ton of beans is reduced accordingly.

Data from Texas Engineering Experiment Station.

TABLE 15.—*Labor requirements for bagging soybean meal and for loading bulk meal in soybean oil mills, by size of mill* [1]

Size of mill	Form of meal produced [2]		Labor required				
			Per ton of meal produced [3]			Per ton of soybeans processed by [4]—	
	Bagged	Bulk	Bagged form	Bulk form	Total	Solvent mills	Screw-press mills
Tons per day	*Percent*	*Percent*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*
150	36	64	0. 108	0. 038	0. 146	0. 114	0. 121
200	32	68	. 096	. 041	. 137	. 107	. 114
300	28	72	. 084	. 043	. 127	. 099	. 105
400	27	73	. 081	. 044	. 125	. 098	. 104
500	25	75	. 075	. 045	. 120	. 094	. 100
600	25	75	. 075	. 045	. 120	. 094	. 100
800	24	76	. 072	. 046	. 118	. 092	. 098
1,000	23	77	. 069	. 046	. 115	. 090	----------

[1] Meal bagging and loading labor for 25-, 50-, and 100-ton-per-day mills is included in labor for extraction departments as shown in tables 13 and 14.

[2] Derived from data made available by the National Soybean Processors Association.

[3] Based on 0.3 man-hour per ton of meal bagged and 0.06 man-hour per ton of bulk meal loaded.

[4] Based on meal yields equivalent to 79 and 83 percent of weight of soybeans by solvent and screw-press processes, respectively.

TABLE 16.—*Total labor requirements and costs of soybean oil mill operations, by type and size of mill, assuming production of bulk meal only*

Type and size of mill	Requirements per ton of soybeans processed [1]					Capacity per man-hour	Cost per bushel of soybeans processed	
	Elevator dept.	Processing dept.	Meal shipping	Miscellaneous	Total		At wage rate of $1.75 per hour	At varying wage rates [2]
Tons per day	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Bushels*	*Cents*	*Cents*
Solvent:								
25	0. 266	2. 971	----------	----------	3. 237	10	16. 994	11. 168
50	. 155	1. 486	----------	----------	1. 641	20	8. 615	5. 661
100	. 104	1. 029	----------	----------	1. 133	29	5. 948	4. 249
150	. 126	. 686	0. 047	0. 076	. 935	36	4. 909	4. 488
200	. 108	. 657	. 047	. 071	. 883	38	4. 636	4. 238
300	. 089	. 514	. 047	. 055	. 705	47	3. 701	3. 701
400	. 095	. 471	. 047	. 051	. 664	50	3. 486	3. 486
500	. 100	. 389	. 047	. 044	. 580	57	3. 045	3. 480
600	. 077	. 362	. 047	. 042	. 528	63	2. 772	3. 168
800	. 063	. 286	. 047	. 033	. 429	78	2. 252	2. 767
1,000	. 065	. 229	. 047	. 028	. 369	90	1. 937	2. 380
Screw-press:								
25	. 266	2. 057	----------	----------	2. 323	14	12. 196	8. 014
50	. 155	1. 029	----------	----------	1. 184	28	6. 216	4. 085
100	. 104	. 571	----------	----------	. 675	49	3. 544	2. 531
150	. 126	. 419	. 050	. 050	. 645	52	3. 386	3. 096
200	. 108	. 457	. 050	. 051	. 666	50	3. 497	3. 197
300	. 089	. 362	. 050	. 040	. 541	62	2. 840	2. 840
400	. 095	. 300	. 050	. 034	. 479	69	2. 515	2. 515
500	. 100	. 251	. 050	. 030	. 431	77	2. 263	2. 586
600	. 077	. 219	. 050	. 028	. 374	89	1. 964	2. 244
800	. 063	. 171	. 050	. 021	. 305	109	1. 601	1. 967

[1] Based on data from Texas Engineering Experiment Station.

[2] Wage rates per hour estimated for different size mills are as follows: $1.15 for 25 and 50 tons per day; $1.25 for 100 tons per day; $1.60 for 150 and 200 tons per day; $1.75 for 300 and 400 tons per day; $2 for 500 and 600 tons per day; and $2.15 for 800 and 1,000 tons per day.

cellaneous labor would be performed by personnel already set up in the jobs described in tables 13 and 14.

Wage Rates

Data from a variety of reliable sources indicated an average hourly wage for all mill labor of approximately $1.15 for mills of 50 tons per day and under, $1.75 as the approximate average for the industry, and $2.15 for mills processing 800 to 1,000 tons per day. From these data, rates were estimated for the different size mills appearing in this study.

Total Man-hours and Labor Cost Per Bushel of Beans by Type and Size of Mill

Total man-hours and labor cost per bushel of beans may now be determined by bringing together the foregoing man-hours for individual operations and wage rates.

As means of placing different-size mills on a comparable basis with respect to their products, total labor requirements were first calculated, as shown in table 16, on the assumption that all mills produced bulk meal only. In table 17 these figures were adjusted in line with the assumption that the 1952–53 season average proportions of bulk and bagged meal were produced.

The relationship between labor requirements and type and size of mill reveals four important traits. First, with the solvent process, producing bulk meal only, total labor ranged from 0.097 man-hour per bushel of beans for tne smallest mill (25 tons per day) to 0.011 man-hour for the largest mill (1,000 tons per day)—over an eightfold gain in labor efficiency representing a saving of approximately 0.09 man-hour per bushel. However, over 80 percent of this saving was accomplished in expanding the size of mill from 25 to only 150 tons per day (figure 1).

Second, an increase in the size of the mill was associated with a somewhat greater decline in man-hours per bushel of beans when the usual proportions of bulk and bagged meal were produced than when bulk meal only was produced (table 17). This was due to the additional labor required for producing bagged meal in higher proportions in small mills.

Third, from a labor standpoint alone, the screw-press process showed an advantage over all sizes of solvent mills, though this advantage became progressively less as size of mill expanded.

TABLE 17.—*Total labor requirements and costs of soybean oil mill operations, by type and size of mill, assuming production of both bulk and bagged meal*

Type and size of mill	Requirements per ton of soybeans processed [1]					Capacity per man-hour	Cost per bushel of soybeans processed	
	Elevator dept.	Processing dept.	Meal bagging and shipping	Miscellaneous	Total		At wage rate of $1.75 per hour	At varying wage rates [2]
Tons per day	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Man-hours*	*Bushels*	*Cents*	*Cents*
Solvent:								
25	0.266	3.886	----------	----------	4.152	8	21.798	14.324
50	.155	1.829	----------	----------	1.984	17	10.416	6.845
100	.104	1.314	----------	----------	1.418	24	7.445	5.318
150	.126	.686	0.114	0.076	1.002	33	5.261	4.810
200	.108	.657	.107	.071	.943	35	4.951	4.526
300	.089	.514	.099	.055	.757	44	3.974	3.974
400	.095	.471	.098	.051	.715	47	3.754	3.754
500	.100	.389	.094	.044	.627	53	3.292	3.762
600	.077	.362	.094	.042	.575	58	3.019	3.450
800	.063	.286	.092	.033	.474	70	2.489	3.057
1,000	.065	.229	.090	.028	.412	81	2.163	2.657
Screw-press:								
25	.266	2.057	----------	----------	2.323	14	12.196	8.014
50	.155	1.029	----------	----------	1.184	28	6.216	4.085
100	.104	.857	----------	----------	.961	35	5.045	3.604
150	.126	.419	.121	.050	.716	47	3.759	3.437
200	.108	.457	.114	.051	.730	46	3.833	3.504
300	.089	.362	.105	.040	.596	56	3.129	3.129
400	.095	.300	.104	.034	.533	63	2.798	2.798
500	.100	.251	.100	.030	.481	69	2.525	2.886
600	.077	.219	.100	.028	.424	79	2.226	2.544
800	.063	.171	.098	.021	.353	94	1.853	2.277

[1] Based on data from Texas Engineering Experiment Station

[2] Wage rates per hour estimated for different size mills are as follows: $1.15 for 25 and 50 tons per day; $1.25 for 100 tons per day; $1.60 for 150 and 200 tons per day; $1.75 for 300 and 400 tons per day; $2 for 500 and 600 tons per day; and $2.15 for 800 and 1,000 tons per day.

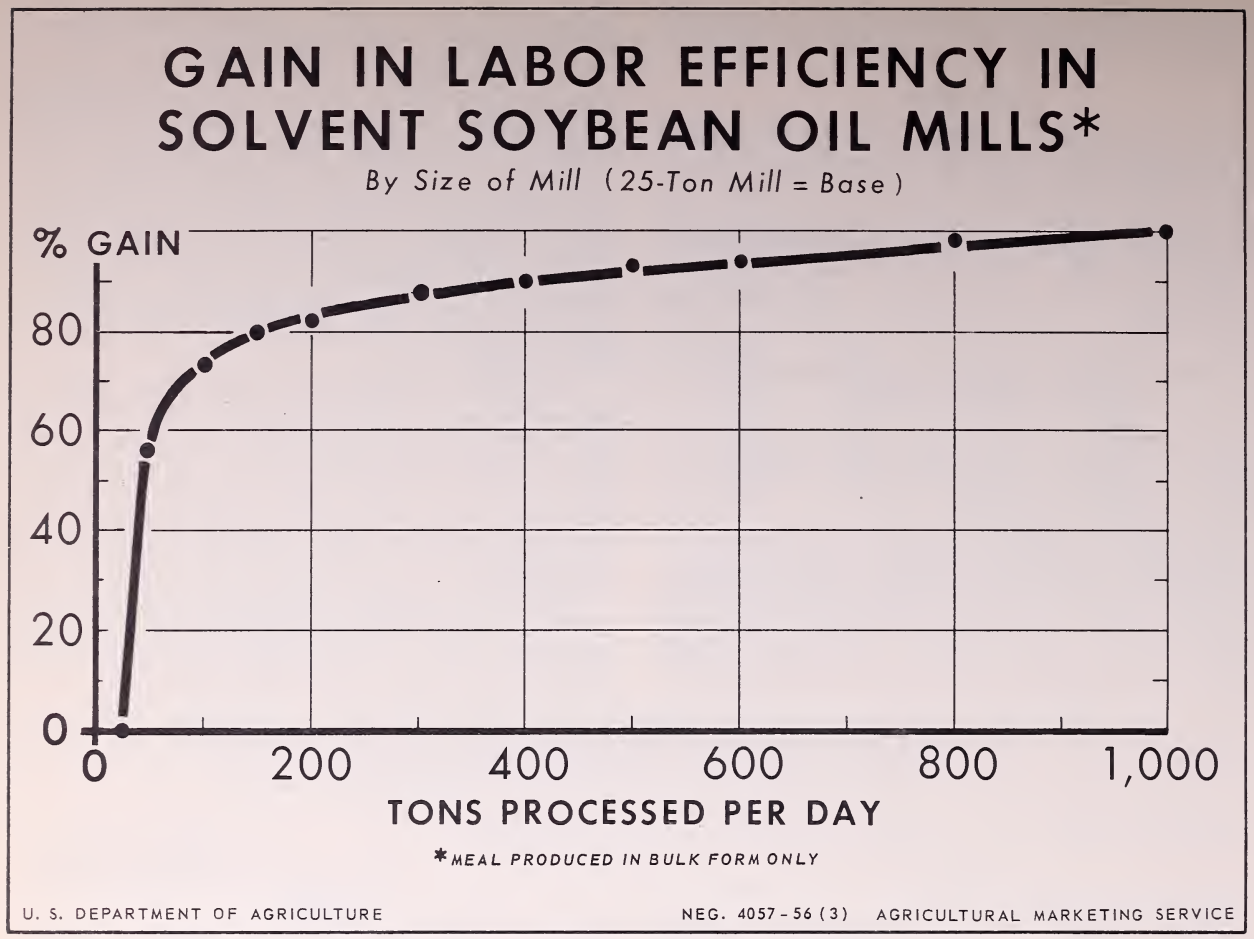


FIGURE 1.—Gain in labor efficiency in solvent soybean oil mills.

Fourth, increase in the size of mill was associated with a greater saving in man-hours than in labor cost per ton of beans, owing to higher wage rates for larger mills. For example, if we assume the production of bulk meal only, the 150-ton-per-day solvent mill used only 29 percent as many man-hours per bushel of beans as the 25-ton mill, but its labor cost was over 40 percent of the cost of the 25-ton mill because its wage rate was $1.60 per man-hour as compared to $1.15 for the small mill.

SALARIES AND GENERAL ADMINISTRATIVE SERVICES

In addition to costs of administration, general administrative expense includes charges for (1) company auto and travel; (2) office expenses such as telephone and telegraph, postage, printing, and office supples; and (3) other expenses like charges for legal services, audit, research, donations, membership dues, and subscriptions.

Data for salaries and general administrative expense were available in terms of the annual total bushels of soybeans processed rather than in terms of daily crushing capacity. (Table 18.)

TABLE 18.—*Estimated cost to soybean oil mills for salaries and general administrative services per bushel of soybeans processed, 1952–53 season*

Volume of soybeans processed (1,000 bushels)	Salaries	General administrative services [1]
	Cents	*Cents*
275	4. 050	0. 961
550	3. 902	1. 183
1,100	3. 623	1. 601
1,650	3. 366	1. 986
2,200	3. 132	2. 338
3,300	2. 730	2. 942
4,400	2. 416	3. 413
5,500	2. 193	3. 751
6,600	2. 058	3. 956
8,800	2. 056	3. 967
11,000	2. 411	3. 447

[1] Includes administrative, travel and automobile, office and other related expenses.

Based on analysis of data made available by the National Soybean Processors Association. Estimates are based on costs for 1951 and 1952 operating seasons of mills located in Illinois, Indiana, Iowa, Minnesota, Missouri, and Ohio.

TABLE 19.—*Workmen's compensation, general liability, social security, and unemployment insurance rates for soybean oil mills per $100 of payroll, 1952–53 season*

Type of rate	Ohio	Indiana	Illinois	Iowa	Minnesota	Average [1]
Workmen's compensation:						
Plant workers:	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Solvent mills	1. 87	2. 30	3. 18	2. 23	3. 66	2. 71
Screw-press mills	1. 87	1. 17	1. 73	1. 22	2. 04	1. 60
Office workers	. 05	. 05	. 06	. 06	. 08	. 06
General liability: Visitors around plant:						
Bodily injury:						
Solvent mills	. 035	. 030	. 030	. 040	. 035	. 033
Screw-press mills	. 035	. 030	. 030	. 040	. 035	. 033
Property damage:						
Solvent mills	. 025	. 025	. 025	. 025	. 025	. 025
Screw-press mills	. 015	. 015	. 015	. 015	. 015	. 015
Social security and unemployment insurance	3. 00	3. 00	3. 00	3. 00	3. 00	3. 00

[1] Weighted by bushels of soybeans processed in each State, 1949–1951 average. From State rating manuals.

WELFARE RISKS

Three types of cost were included in the category of welfare risks: (1) Workmen's compensation, (2) general liability, and (3) social security. This study used the average of each of these items for the six major soybean States (table 19).

MAINTENANCE AND REPAIRS

Maintenance and repair costs shown in table 20 are estimates of the relationship of maintenance and repair costs and different size mills.

Data were based on four sources: (1) Seventeen small soybean mills showed an average maintenance and repair cost of 70.6 cents per ton, ranging from $0.12 to $1.19. These costs were exclusive of any soybean storage, but included the boilerhouse. Sixteen of these mills had an average operating rate of 50.5 tons per day, ranging from 20 to 100 tons per day. Fifteen were screw-press mills and 2 were solvents of 35 and 80 tons per day.

TABLE 20.—*Estimated maintenance and repair costs of solvent and screw-press soybean oil mills, by size of mill, 1952–53 season*

Size of mill	Cost per ton		Cost per bushel		Cost of solvent as percentage of screw-press
	Solvent	Screw-press	Solvent	Screw-press	
Tons per day	*Cents*	*Cents*	*Cents*	*Cents*	*Percent*
25	61	80	1. 83	2. 40	76
50	55	74	1. 65	2. 22	74
100	50	69	1. 50	2. 07	72
150	47	66	1. 41	1. 98	71
200	45	65	1. 35	1. 95	69
300	42	62	1. 26	1. 86	68
400	40	60	1. 20	1. 80	67
500	39	59	1. 17	1. 77	66
600	38	58	1. 14	1. 74	66
800	36	56	1. 08	1. 68	64
1,000	35	-------	1. 05	-------	-------

Data from Texas Engineering Experiment Station.

(2) Another estimate, for mills of 75 to 200 tons per day, gave maintenance and repair cost as 3 percent of investment cost in processing equipment and building (exclusive of bean storage, boilerhouse, and other facilities). By this method, costs ranged from 69 to 36 cents per ton for the 75, and 200-ton-per-day solvent mills, respectively. (3) Kenyon, Kruse, and Clark[6] gave a ratio of solvent to screw-press maintenance and repair costs of 0.64 for equal sizes of mills operating at about 400 tons per day. This figure was an average over several years. (4) A firm operating a number of solvent mills reported maintenance and repair cost to run from 35 to 50 cents per ton.

The maintenance and repair costs based on these data from four independent sources fell near a straight line when plotted on logarithmic scales.[7]

UTILITIES

Utilities included two types of services: electric power and water.

Electric Power

Mills in this report were completely electrified. Their energy charges were based on: (1) the total kilowatt-hour consumption, and (2) the highest average kilowatt demand during any 15-minute portion of each power billing period (month).

POWER CONSUMPTION. A figure of 40 kilowatt-hours per ton of beans was used for all solvent mills and 57 kilowatt-hours for all screw-press mills. The estimated requirements for the operations included in these totals are shown in table 21.

In case of the solvent process, estimates were based on a variety of sources, including amperage readings on motors in actual mills and calculated

[6] Kenyon, Richard L., Kruse, N. F., and Clark, S. P. SOLVENT EXTRACTION OF OIL FROM SOYBEANS. Indus. and Engin. Chem. 40 (2): 186–194. 1948.

[7] This would be expected since investment costs versus mill size usually fall near a straight line when plotted on double logarithmic scales and because maintenance and repair costs are often stated to be certain percentages of investment costs.

values from horsepower formulas or motor sizes specified with machinery. The total kilowatt-hours was checked against the energy used by a medium-size mill where there was exact knowledge of the operations involved.

A considerable amount of data indicated that screw presses require approximately a constant amount of power per ton and will produce cake of the same oil content over a range of press throughputs. The calculations of power required and oil and meal produced were made under this assumption. In line with this assumption, 57 kilowatt-hours per ton of beans was used for all screw-press operations producing 4.0 percent oil in meal of 12.0 percent moisture.

Power Demand. In approximating the highest average power demand in kilowatts, total demand was broken into two components: processing demand and elevator demand. The latter included the power requirements for receiving and storing beans, whereas the former included requirements for all processing operations specified in table 21. The demand for boilerhouse, machine shop, and office was not estimated in detail and was assumed to be included in the two large demands.

Table 21.—*Estimated electric power consumption required per ton of soybeans processed in solvent and screw-press soybean oil mills, by type of operation*

Operation	Power consumption per ton of soybeans processed by—	
	Solvent mill	Screw-press mill
	Kilowatt-hours	*Kilowatt-hours*
Receiving and storing soybeans [1]	3.0	3.0
Grinding screenings	.6	.6
Cracking soybeans	3.4	3.4
Conditioning [2]	1.5	----
Flaking [2]	8.2	----
Extraction [2]	.5	----
Water cooling and pumping [2]	4.1	----
Desolventizing and toasting meal [2]	3.5	----
Drying cracked soybeans [3]	----	5.6
Screw-pressing [3]	----	30.0
Cooling presses [3]	----	.9
Breaking cake [3]	----	1.0
Cooling cake [3]	----	1.5
Cooling meal [2]	2.0	----
Grinding meal	4.0	3.4
Aspiration [2 4]	.4	----
Lighting for entire mill	1.4	1.4
Miscellaneous [5]	7.0	6.0
Total [6]	40.0	57.0

[1] Does not include drying of whole soybeans.
[2] Solvent mills only.
[3] Screw-press mills only.
[4] For equipment in preparation and meal processing department.
[5] Includes conveying soybeans from elevator and throughout the preparation, oil extraction (screw-press mills only), and meal processing departments, screening meal, loading of finished meal and oil, and other miscellaneous power requirements for the mills.
[6] Rounded totals.

Data from Texas Engineering Experiment Station.

Processing Power Demand. Processing power demand was based on the above overall 40 kilowatt-hours per ton of beans for any solvent mill and 57 kilowatt-hours for any screw-press mill. In these terms, the demand per ton of daily capacity was 1.67 kilowatts for each solvent mill and 2.38 for each screw-press mill.

Elevator Power Demand. Maximum electric power demands for bean storage facilities are those which might be experienced if all facilities were operated under full load at the same time. Table 68 in the appendix shows these maximum demands for individual bean storage facilities in terms of kilowatts per ton of daily crushing capacity for mills in the Soybean Belt.

However, actual billing demands (highest average 15-minute power demand during a month) would always be considerably less than these figures except under extremely unusual circumstances, since elevator operations as a rule are highly discontinuous.

In developing an estimate to use for elevator billing demand, maximum demands were calculated for southern mills like those for northern mills in table 68. The northern and southern demands were then averaged and divided by 2 for all mills smaller than 600 tons per day, and the values plotted as first approximations of billing demand. This procedure considerably smoothed the data and resulted in the curve shown in figure 2. Separate curves are shown for northern and southern mills of 600 to 1,000 tons per day which had maximum demands that were different because of the inclusion of boxcar unloaders in northern mills.

These relationships were checked against the actual elevator billing demands of 3 small mills, ranging fron approximately 20 to 190 tons per day, and for 1 mill with equipment approximating that specified in table 45 for 1,000-ton-per-day northern mills. The curve plotted for mills smaller than 600 tons per day falls exactly on the check data for a 35-ton-per-day mill but was appreciably above the check data for mills at 100 and 190 tons per day, probably because the model mills in this study were provided with equipment for more rapid unloading and handling of beans than that of the check mills. The curves for northern and southern mills, respectively, of 600 through 1,000 tons per day checked very reasonably with the one large mill mentioned above.

These curves represent the best estimates that can be made from available data of the relationship between size of mill and storage demand. Such data are difficult to get because mills in most

cases get both the storage and processing power through the same meter.

The check data did not show a great deal of variation in power demand from month to month. In fact, two-thirds of the monthly values fell within approximately plus or minus 10 percent of the average. Elevator power consumption varies by months because of variation in bean receipts. However, this fact is consistent with a relatively stable power demand since unloading only a few carloads or truckloads of beans per month, one right after another, might well result in the same billing demand as if the unloading were more or less continuous throughout the whole month.

For these reasons in this study we assumed that variations in monthly billing demand were not significant, even though the volume of beans unloaded varies widely from month to month. The average demands for different size mills are shown in table 22.

Electric Power Rate. The power rate, used in calculating electric power charges for mills in this study (table 23), is not necessarily identical with that of any particular mill, but is typical of those available throughout the Soybean Belt.

Basic demand and energy charges are often subject to adjustments, depending on such conditions as power factor, ownership of transformers, and metering voltage. When applicable, such adjustments usually affect the base rates about 5 percent and seldom as much as 10 percent. As this margin is within a reasonable tolerance of error, these adjustments were disregarded in this study.

Power Costs Per Bushel of Beans. Table 24 shows the variation of electric power costs per bushel of beans with type and size of mill, based on the foregoing power requirements and rates. The solvent process showed a cost advantage over the screw-press process of approximately 0.4 to 0.7 cent per bushel of beans. Little reductions in power cost per bushel were associated with increases in size of mill beyond 500 tons per day.

Water

Water is necessary for use in processing soybeans, and for fire protection.

Water Requirements. Water is used for: (1) Sanitation, (2) steam production, and (3) condensing vaporized solvent.

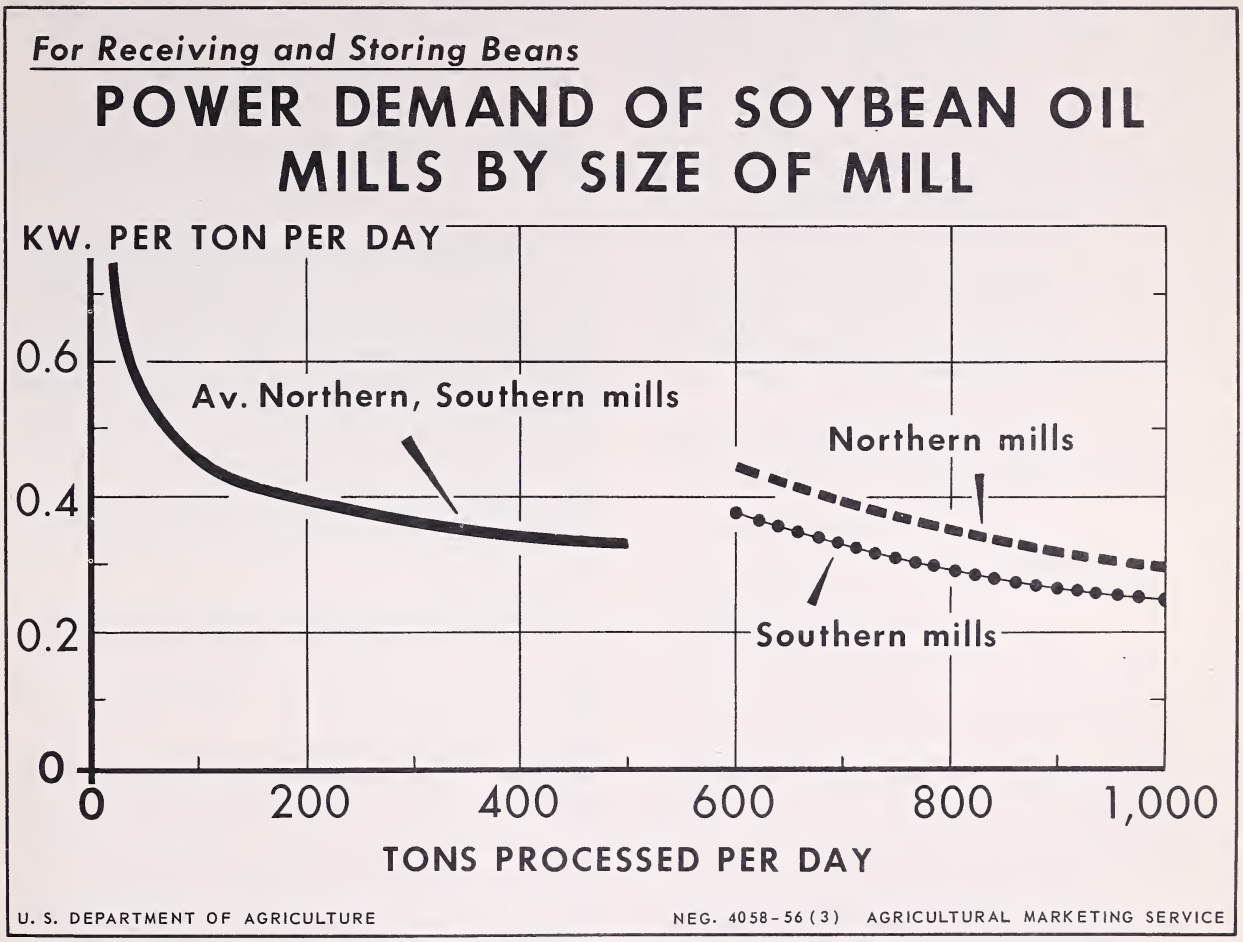


Figure 2.

TABLE 22.—*Electric power demands of soybean oil mills, by type and size of mill*

Type and size of mill	Power demand per ton per day for—			Total power demand for mill (average per month)[2]
	Elevator department [1]	Processing departments	Total	
Tons per day				
Solvent:	*Kilowatts*	*Kilowatts*	*Kilowatts*	*Kilowatts*
25	0.75	1.67	2.42	61
50	.53	1.67	2.20	110
100	.46	1.67	2.13	213
150	.42	1.67	2.09	314
200	.40	1.67	2.07	414
300	.38	1.67	2.05	615
400	.35	1.67	2.02	808
500	.34	1.67	2.01	1,005
600	.45	1.67	2.12	1,272
800	.35	1.67	2.02	1,616
1,000	.30	1.67	1.97	1,970
Screw press:				
25	.75	2.38	3.13	78
50	.53	2.38	2.91	146
100	.46	2.38	2.84	284
150	.42	2.38	2.80	420
200	.40	2.38	2.78	556
300	.38	2.38	2.76	828
400	.35	2.38	2.73	1,092
500	.34	2.38	2.72	1,360
600	.45	2.38	2.83	1,698
800	.35	2.38	2.73	2,184

[1] From fig. 2.
[2] Size of mill times demand per ton per day.

Data from Texas Engineering Experiment Station.

All mills were provided with facilities for recirculating cooling water, except the 1- and 2-press screw-press mills because it was assumed that such facilities would not be economical for them. This resulted in a higher water consumption rate for these mills.

These estimated requirements are shown in table 25 for different mills.

WATER RATES. It was assumed that water costs would be approximately the same whether a mill secured its water from a municipal supply or provided its own through well and pump installation.

To simplify calculations, the first alternative was employed. A typical water-rate schedule applicable for industrial uses was selected through comparing the water costs (including charges for private fire protection connections) for a small, a medium, and a large mill as determined by the water-rate schedules of the soybean oil mill towns in the six main soybean-producing States. The rate used was as follows:

First 10,000 cu. ft. per quarter @ $0.33 per 100 cu. ft.
Next 50,000 cu. ft. per quarter @ $0.23 per 100 cu. ft.
Next 140,000 cu. ft. per quarter @ $0.15 per 100 cu. ft.
Next 400,000 cu. ft. per quarter @ $0.12½ per 100 cu. ft.
Next 1,400,000 cu. ft. per quarter @ $0.10 per 100 cu. ft.
Next 4,000,000 cu. ft. per quarter @ $0.08½ per 100 cu. ft.
All over 6,000,000 cu. ft. per quarter @ $0.07½ per 100 cu. ft.
Plus a service charge per quarter of $4.50.

TABLE 23.—*Typical 1953 electric power rate used in estimating power costs for soybean oil mills*[1]

Rate basis	Monthly charges	
	Per kilowatt of demand	Per kilowatt-hour consumed
Demand (kilowatts):	*Dollars*	*Cents*
First 50	1.75	----------
Next 100	1.50	----------
Balance	1.25	----------
Energy (kilowatt-hours):		
First 30,000	----------	1.30
Next 70,000	----------	1.00
Next 100,000	----------	.75
Balance	----------	.60

[1] Based on analysis of industrial power rate schedules for 1953 available to 65 soybean oil mills in Illinois, Indiana, Iowa, and Ohio.

SUPPLIES

Supplies included fuel oil, hexane, and meal bags.

Fuel Oil

As all mills in this study were provided with oil-fired boilers, fuel oil was the only type of fuel considered. Fuel oil consumption was based on the amounts of steam needed for various purposes.

STEAM CONSUMPTION. For beans of approximately 12 percent moisture, 1,200 pounds of steam was allowed per ton of beans for solvent mills and 600 pounds for screw-press mills. These figures included steam for heating buildings and all other uses. Although drying equipment was provided in all mills, no allowance for steam was made for drying beans having more than 12 percent moisture, as most beans have had low mositure content in recent years.

FUEL-OIL CONSUMPTION. Fuel-oil consumption rates were determined on the basis of the following: (1) All manufacturers of package-type steam generators guarantee at least 80 percent fuel efficiency when firing gas or oil. (2) It was assumed that 1,100 British thermal units are required per pound of steam. (3) The 25- and 50-ton-per-day screw-press mills and the 25-ton-per-day solvent mill were provided with steam generators designed to burn No. 2 fuel oil or gas. All other mills had generators designed to use either No. 6 fuel oil or gas. (4) The heating values are approximately 145,000 British thermal units per gallon for No. 2 oil and 152,000 for No. 6 oil.

TABLE 24.—*Electric power costs of soybean oil mills, by type and size of mill, 1952–53 season* [1]

Type and size of mill	Average electric power used per month				Total power cost per month	Annual power cost	
	Demand		Energy			Total	Per bushel of soybeans
	Amount	Cost	Amount	Cost			
Tons per day Solvent:	*Kilowatts*	*Dollars*	*Kilowatt-hours*	*Dollars*	*Dollars*	*Dollars*	*Cents*
25	61	104	27, 500	358	462	5, 544	2. 016
50	110	178	55, 000	640	818	9, 816	1. 785
100	213	316	110, 000	1, 165	1, 481	17, 772	1. 616
150	314	443	165, 000	1, 578	2, 021	24, 252	1. 470
200	414	568	220, 000	1, 960	2, 528	30, 336	1. 379
300	615	819	330, 000	2, 620	3, 439	41, 268	1. 251
400	808	1, 060	440, 000	3, 280	4, 340	52, 080	1. 184
500	1, 005	1, 306	550, 000	3, 940	5, 246	62, 952	1. 145
600	1, 272	1, 640	660, 000	4, 600	6, 240	74, 880	1. 135
800	1, 616	2, 070	880, 000	5, 920	7, 990	95, 880	1. 090
1,000	1, 970	2, 513	1, 100, 000	7, 240	9, 753	117, 036	1. 064
Screw press:							
25	78	130	39, 188	482	612	7, 344	2. 671
50	146	232	78, 375	874	1, 106	13, 272	2. 413
100	284	405	156, 750	1, 516	1, 921	23, 052	2. 096
150	420	575	235, 125	2, 051	2, 626	31, 512	1. 910
200	556	745	313, 500	2, 521	3, 266	39, 192	1. 781
300	828	1, 085	470, 250	3, 462	4, 547	54, 564	1. 653
400	1, 092	1, 415	627, 000	4, 402	5, 817	69, 804	1. 586
500	1, 360	1, 750	783, 750	5, 343	7, 093	85, 116	1. 548
600	1, 698	2, 173	940, 500	6, 283	8, 456	101, 472	1. 537
800	2, 184	2, 780	1, 254, 000	8, 164	10, 944	131, 328	1. 492

[1] Based on tables 21, 22, and 23.

The number of gallons of No. 2 fuel oil required per 1,000 pounds of steam is 9.48. If No. 6 fuel oil is used, the requirement per 1,000 pounds of steam is 9.05 gallons.

Fuel-oil consumption per ton for different mills is shown in table 26.

FUEL-OIL PRICES. The prices used for fuel oil were 11 cents per gallon for No. 2 oil, and 6 cents for No. 6 oil, and were based on reports of fuel oil producers on their average f. o. b. Decatur, Ill., prices for October 1952 through September 1953.

Solvent Loss

A considerable amount of data showed that solvent loss varies from about 1 to 2 gallons per ton for mills between 500 and 100 tons per day. The problem was to make a reasonable differentiation among mills of different sizes. When values

TABLE 25.—*Water requirements per ton of soybeans processed in solvent and screw-press soybean oil mills, by type and size of mill*

Size of mill	Solvent mill	Screw-press mill
	Gallons	*Gallons*
25–50 tons per day	300	[1] 360
100–1,000 tons per day	300	100

[1] These mills were not provided with facilities for recirculating cooling water.

Data from Texas Engineering Experiment Station.

TABLE 26.—*Fuel-oil requirement and cost for soybean oil mills, by type and size of mill, 1952–53 season*

Type and size of mill	Requirement [1]		Cost [3]	
	Per 1,000 lbs. of steam	Per ton of beans [2]	Per ton of beans	Per bushel of beans
Solvent:	*Gallons*	*Gallons*	*Dollars*	*Cents*
25 tons per day	[4] 9. 48	11. 38	1. 2518	3. 755
50–100 tons per day	[5] 9. 05	10. 86	. 6516	1. 955
Screw press:				
25–50 tons per day	[4] 9. 48	5. 69	. 6259	1. 878
100–800 tons per day	[5] 9. 05	5. 43	. 3258	. 977

[1] Based on data from Texas Engineering Experiment Station.

[2] 1,200 and 600 pounds of steam required per ton of soybeans processed by solvent and screw-press mills, respectively.

[3] Based on f. o. b. Decatur, Ill., prices reported by fuel-oil producers of 11 cents per gallon for No. 2 fuel oil, and 6 cents per gallon for No. 6 fuel oil. Prices reported were for October 1952 through September 1953.

[4] No. 2 fuel oil.

[5] No. 6 fuel oil.

TABLE 27.—*Estimated solvent loss and cost for processing soybeans in solvent soybean oil mills, by size of mill, 1952–53 season*

Size of mill	Solvent loss per ton [1]	Solvent cost [2]	
		Per ton	Per bushel
Tons per day	*Gallons*	*Cents*	*Cents*
25	3.0	57.0	1.710
50	2.5	47.5	1.425
100	2.0	38.0	1.140
150	1.8	34.2	1.026
200	1.6	30.4	.912
300	1.4	26.6	.798
400	1.3	24.7	.741
500	1.2	22.8	.684
600	1.2	22.8	.684
800	1.1	20.9	.627
1,000	1.0	19.0	.570

[1] Data supplied by Texas Engineering Experiment Station.

[2] Solvent cost of 19 cents per gallon used was based on average prices of hexane solvent delivered at Decatur, Ill., from October 1952 through September 1953, as reported by 3 large commercial suppliers.

of 1 gallon per ton at 1,000 tons per day and 2 gallons per ton at 100 tons per day were plotted on log-log graph paper, the values for all sizes of mills appeared so reasonable that they were selected for use and are shown in table 27.

A mill's solvent loss depends to a large extent upon its equipment, maintenance, and operating practices. Up to a certain size, mills of increasing size would be expected to possess the desirable portions of these factors to increasing extents; therefore solvent loss would be expected to decrease somewhat with increasing size of mill, but at a decreasing rate. In these terms the results of the graph were satisfactory. Even the estimates of losses for mills smaller than 100 tons per day did not look unreasonable, and later checks showed these figures to be reliable estimates. Beyond 400 tons per day, the estimated solvent loss decreases only 0.2 gallon on out to 1,000 tons per day, which also appears reasonable and checks with available data.

A figure of 19 cents per gallon was allowed for hexane solvent.

Meal Bags

Practically all manufacturers of mixed feeds buy their soybean meal in bulk form. Accordingly, bags are required only for export meal or for supplying small feed manufacturers or farmers. Type and grade of meal bags vary widely but it did not appear that such differences need be considered in this study. Therefore, all mills were assumed to use No. 1 10-ounce used burlap bags. The 1952–53 average price of such bags was approximately $180 per thousand, or 18 cents each. Meal yields and the proportion of meal sold in bagged form were used in estimating the costs of meal bags per bushel of beans processed shown in table 31.

LABORATORY SERVICES

The chemical analyses, needed by mills, fall into three main types: (1) For accounting purposes, in calculating the theoretical yield of oil and meal from beans, whole beans are analyzed for moisture and oil. Foreign matter is determined during grading before unloading. (2) For control of the processing operations many analyses may be made of materials in process. (3) Samples of oil from each tank car shipped are analyzed as prescribed in the trading rules of the National Soybean Processors Association (for refining loss, moisture and volatile content, green color, refined and bleached red color, and flashpoint in the case of solvent extracted oil).

Small mills usually have types 1 and 3, and a few essential type 2 analyses done by commercial laboratories. From the records of a group of small mills, 0.14 cent per bushel was used as the average cost for this service.

Large mills usually have control laboratories which perform types 1 and 2 analyses and oftentimes type 3, although much of type 3 is performed by commercial laboratories for large mills too, particularly if the mill is not the member of a chain under one ownership.

The dividing line between small and large mills is one of judgment; however, for the present purpose it was drawn between 100 and 150 tons per day. Laboratory equipment (table 79) and estimates of labor were provided for mills starting with 150 tons per day.

In calculating labor for laboratory work, a detailed estimate was first prepared showing all of the control analyses which mills of different sizes of both types might require. This was then submitted for review to the chief chemist of an operating mill. He suggested 160 analyses per analyst per week be used to estimate the number of analysts required for different sizes of mills. The estimate was then revised to the figures shown in table 28.

As described under salaries on page 14, the figures for all salaries were derived from data made available to the Special Crops Section by the National Soybean Processors Association. Presumably salaries for laboratory supervisors or chief chemists are also included in these data. In some small mills the compensation of laboratory personnel calculated from table 28 might be included also in the salary figures used. If such is the case, the error would be slight and would be on the long instead of the short side.

Commercial laboratories charge $10 per sample of oil for running the analyses. One sample is run for each tank car of oil shipped. Oil yields were estimated to be 11 and 9 pounds for solvent and screw-press processes (table 3). The corresponding costs per bushel were 0.18 and 0.15 cent.

TABLE 28.—*Estimated costs of laboratory services required for solvent and screw-press soybean oil mills, by type and size of mill, 1952–53 season*

Type and size of mill	At mill [1]						Cost at commercial laboratories per bushel of beans [3]	Total cost per bushel of beans
	Analyses run per 7-day week	Analysts required				Cost per bushel of beans [2]		
		Grade A	Grade B	Grade C	Total			
Tons per day	*Number*	*Number*	*Number*	*Number*	*Number*	*Cents*	*Cents*	*Cents*
Solvent:								
25							0. 140	0. 140
50							. 140	. 140
100							. 140	. 140
150	122	1			1	0. 200	. 183	. 383
200	130	1			1	. 150	. 183	. 333
300	204	1	1		2	. 194	. 183	. 377
400	218	1	1		2	. 146	. 183	. 329
500	232	1	1		2	. 117	. 183	. 300
600	359	1	1	1	3	. 140	. 183	. 323
800	387	1	1	1	3	. 105	. 183	. 288
1,000	416	1	1	1	3	. 084	. 183	. 267
Screw press:								
25							. 140	. 140
50							. 140	. 140
100							. 140	. 140
150	139	1			1	. 200	. 150	. 350
200	156	1			1	. 150	. 150	. 300
300	214	1	1		2	. 194	. 150	. 344
400	264	1	1		2	. 146	. 150	. 296
500	300	1	1	1	3	. 168	. 150	. 318
600	337	1	1	1	3	. 140	. 150	. 290
800	395	1	1	1	3	. 105	. 150	. 255

[1] Data obtained from Texas Engineering Experiment Station. Small mills were assumed to have all analyses done by commercial laboratories.

[2] Based on average wage rates of $1.75, $1.65, and $1.50 per hour for grades A, B, and C analysts for a 40-hour week.

[3] Costs for 25-, 50-, and 100-ton-per-day mills are based on the average cost of 14 small mills. Costs for larger mills based on reported laboratory charges of $10 per sample for FFA, refining loss, color, R. B. color, M and V, and flashpoint.

Based on information made available by some firms doing their own analytical control work, the average wage scale for different grade analysts was as follows:

Analysts	*Average wage per hour (dollars)*
Grade A	1. 75
Grade B	1. 65
Grade C	1. 50

In terms of the foregoing information, estimated costs of laboratory services for solvent and screw-press mills of different sizes are shown in table 28.

INSURANCE

For reasons previously stated (p. 5), insurance was charged at the rate of 18 cents per $100 value of the soybeans, meal, and oil in storage at mills. The amount of such insurance was calculated on the basis of average stocks in storage (table 29).

PRODUCT SELLING SERVICES

Costs were estimated for two sales services: Brokerage on oil and meal, and taxes and licenses which are levied in some soybean producing States.

Brokerage on Oil and Meal

As of the 1952–53 season, the customary charge for brokerage was $25 per tank car of oil and 50 cents per ton of meal. Brokerage charges were applied to all oil sales but only to the meal sales which were shipped by rail. The amount of meal shipped by rail was approximately equal to the meal portion of the soybeans received by rail, shown in table 11.

Differences between product yielded by the solvent and the screw-press process were taken account of in estimating the brokerage costs for both products.

Taxes and Licenses

This study used 0.07 cent per bushel of beans in calculating sales tax and license charges. This figure was the average for 10 soybean oil mills, from which data were available during the 1952–53 season.

The foregoing selling costs are totaled for each type of mill and are shown on a bushel basis in table 31.

TABLE 29.—*Estimated cost of insurance on soybeans and soybean products in oil mills, by size of mill, 1952–53 season*

Size of mill	Value insured						Total	Insurance cost [4]	
	Soybeans [1]		Soybean meal [2]		Soybean oil [3]			Total	Per bushel
	Stocks	Value	Stocks	Value	Stocks	Value			
Tons per day	*1,000 bushels*	*Dollars*	*Tons*	*Dollars*	*1,000 gallons*	*Dollars*	*Dollars*	*Dollars*	*Cents*
25	44	120, 956	100	8, 000	7	6, 300	135, 256	243	0. 088
50	88	243, 232	200	16, 000	14	12, 600	271, 832	489	. 089
100	176	492, 624	410	32, 800	28	25, 200	550, 624	991	. 090
150	264	745, 008	490	39, 200	42	37, 800	822, 008	1, 480	. 090
200	352	993, 344	650	52, 000	56	50, 400	1, 095, 744	1, 972	. 090
300	528	1, 495, 824	740	59, 200	84	75, 600	1, 630, 624	2, 935	. 089
400	704	1, 994, 432	980	78, 400	112	100, 800	2, 173, 632	3, 913	. 089
500	880	2, 500, 080	1, 230	98, 400	140	126, 000	2, 724, 480	4, 904	. 089
600	1, 056	3, 000, 096	1, 470	117, 600	168	151, 200	3, 268, 896	5, 884	. 089
800	1, 408	4, 000, 128	1, 960	156, 800	224	201, 600	4, 358, 528	7, 845	. 089
1,000	1, 760	5, 000, 160	2, 450	196, 000	280	252, 000	5, 448, 160	9, 807	. 089

[1] Quantity of stocks based on monthly average on hand equivalent to 16 percent of annual crush. Value equal to delivered cost at mill as shown in table 10.

[2] Stocks of meal equivalent to normal storage requirements (page 69). Meal priced at $80 per ton.

[3] Stocks of oil equivalent to approximately 7 days' production. Oil priced at 12 cents per pound or 90 cents per gallon.

[4] Insurance cost estimated at 18 cents per $100 of insured value.

WORKING CAPITAL

Working capital as here used consists of such funds as are necessary to meet expenditures that cannot be met from current income.

As mills usually acquire most of their annual supply of beans in the early part of the season, large amounts of working capital are needed for soybean purchases. Additional working capital is needed to meet expenses during lags between products sales and receipt of payments, during shutdown periods for repair purposes or other reasons, and for acquiring working inventories such as meal bags, fuel oil, repair parts, and other supplies.

Whether borrowed or owned by the operator, such funds involve a cost commonly recognized as equivalent to the prevailing interest rate on short-term credit.

Interest Rates

These rates vary somewhat, depending on the amount of funds involved. Those used in this study, as shown in the following tabulation, are the 1952 average rates on short-term loans to business by banks in 19 selected cities as reported by the Federal Reserve Board.[8]

Size of loan (dollars)	*Rate (percent per annum)*
1,000–10,000	4. 9
10,000–100,000	4. 2
100,000–200,000	3. 7
200,000 and over	3. 3

[8] Board of Governors of Federal Reserve System. FINANCIAL, INDUSTRIAL, COMMERCIAL STATISTICS. U. S. Fed. Reserve Bul. 40 (7): 745. 1954.

Amount of Working Capital Charges

The amount of working capital needed to maintain mill operation is highly variable, owing to the seasonality of soybean purchases. Other needs for working capital are fairly stable, especially under year-round operations. Data on the monthly current assets and liabilities would provide the best means of determining the average monthly working capital requirements of different mills. However, such data were not available. Soybean procurements are exceptionally heavy in the fall and early winter and then become progressively less than the daily crush in the spring and summer. Interest, therefore, was charged against the value of the average monthly inventory of soybeans for the full 12-month period. (Cost of beans at "the mill door" was used in determining the value of beans in storage.)

Since other working capital needs are relatively stable from month to month, it was assumed that income from the first month's operations would be sufficient to meet expenditures of the second month, and so on for each successive month throughout the year. Therefore, working capital charges for needs other than seed purchases were approximated by applying the above interest rates over a 1-month period to the average monthly expenditures (table 30).

IV. MILL ECONOMIES

Because of data developed in the foregoing chapters, attention can now be directed to the central concern of this study: (1) the relationship of variation in sizes of mills with variations in

TABLE 30.—*Estimated charges for working capital of soybean oil mills, by type and size of mill, 1952–53 season*

Type and size of mill	Amount of working capital required for:		Working capital charges [3]			
	Soybean purchases [1]	Operating expenses [2]	Soybean purchases	Operating expenses	Total	Per bushel of soybeans
Tons per day	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Cents*
Solvent:						
25	121, 000	9, 000	4, 477	37	4, 514	1. 641
50	243, 000	12, 000	8, 019	42	8, 061	1. 466
100	493, 000	21, 000	16, 269	74	16, 343	1. 486
150	745, 000	29, 000	24, 585	102	24, 687	1. 496
200	993, 000	38, 000	32, 769	133	32, 902	1. 496
300	1, 496, 000	54, 000	49, 368	189	49, 557	1. 501
400	1, 994, 000	71, 000	65, 802	249	66, 051	1. 501
500	2, 500, 000	88, 000	82, 500	308	82, 808	1. 506
600	3, 000, 000	104, 000	99, 000	320	99, 320	1. 505
800	4, 000, 000	133, 000	132, 000	410	132, 410	1. 505
1,000	5, 000, 000	160, 000	165, 000	493	165, 493	1. 504
Screw press:						
25	121, 000	7, 000	4, 477	29	4, 506	1. 639
50	243, 000	11, 000	8, 019	39	8, 058	1. 465
100	493, 000	18, 000	16, 269	63	16, 332	1. 485
150	745, 000	26, 000	24, 585	91	24, 676	1. 496
200	993, 000	34, 000	32, 769	119	32, 888	1. 495
300	1, 496, 000	49, 000	49, 368	172	49, 540	1. 501
400	1, 994, 000	64, 000	65, 802	224	66, 026	1. 501
500	2, 500, 000	80, 000	82, 500	280	82, 780	1. 505
600	3, 000, 000	95, 000	99, 000	333	99, 333	1. 505
800	4, 000, 000	123, 000	132, 000	379	132, 379	1. 504

[1] Based on 16 percent of annual soybean purchases at delivered costs per bushel shown in table 10.

[2] Based on 1 month's operating expenses.

[3] Capital for soybean purchases borrowed for 1 year; capital for operating expenses borrowed for 1 month at the following rates:

Size of loan (dollars)	*Rate (percent per annum)*
1,000–10,000	4. 9
10,000–100,000	4. 2
100,000–200,000	3. 7
200,000 and over	3. 3

costs and revenue per bushel of beans processed, and (2) the extent, if any, to which industrywide increases in the sizes of mills could make possible higher gross returns to farmers for their soybeans.

Discussion of these matters is carried on in terms of solvent mills with only occasional reference to screw-press mills. However, the accompanying tables carry comparable data on both types of mills, as most of these data are needed in handling the secondary purpose of the study: At approximately what point in the scale of operations do solvent mills come to earn more net revenue per bushel of beans and per dollar of investment than screw-press mills?

VARIATION OF COST WITH SIZE OF MILL

The first question to be resolved is how cost per bushel of soybeans processed changes with change in sizes of mills, assuming typical operating conditions and 1952–53 cost-price relationships.

To serve various comparisons often needed for different mills, variation of costs with size of mill was developed under alternative assumptions. First it was assumed that the different sizes of mills produced the normal proportions of bagged and bulk meal (table 7), and second, that they produced bulk meal only.

VARIATION OF COST WITH SIZE OF MILL, ASSUMING PRODUCTION OF USUAL PROPORTIONS OF BULK AND BAGGED MEAL

Variations of costs with sizes of mills are shown in table 31, assuming that mills produce bulk and bagged meal.

Characteristics of the Cost-Volume Relationship

Three characteristics of this relationship are particularly noteworthy. First, increasing the size of solvent mills from 25 to 1,000 tons' daily capacity was associated with a decline of approximately 28 cents per bushel in total processing costs, including acquisition costs of beans.

Second, with three minor exceptions, cost declined with each increase in size of mill but at a decreasing rate. As indicated in table 32, the first doubling in size of solvent mills (from 25 to 50 tons per day) was associated with a 31-percent decline in cost per bushel, whereas the second

TABLE 31.—*Estimated processing costs per bushel of soybeans by type and size of mill, 1952–53 season*[1]

Type and size of mill	Soybeans processed annually	Acquisition of soybeans			Plant					Operating		
		Intermediary charges	Transportation	Total	Depreciation	Interest	Taxes	Insurance	Total	Labor	Electric power	Fuel oil
Tons per day	*1,000 bushels*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
Solvent:												
25	275	0. 000	1. 900	1. 900	8. 058	8. 872	3. 439	0. 396	20. 765	14. 324	2. 016	3. 755
50	550	1. 500	1. 900	3. 400	4. 882	5. 499	2. 132	. 246	12. 759	6. 845	1. 785	1. 955
100	1, 100	5. 000	1. 900	6. 900	3. 397	3. 948	1. 526	. 177	9. 048	5. 318	1. 616	1. 955
150	1, 650	6. 500	2. 700	9. 200	3. 062	3. 640	1. 410	. 163	8. 275	4. 810	1. 470	1. 955
200	2, 200	6. 500	2. 700	9. 200	2. 801	3. 372	1. 306	. 151	7. 630	4. 526	1. 379	1. 955
300	3, 300	7. 100	3. 200	10. 300	2. 393	2. 867	1. 108	. 128	6. 496	3. 974	1. 251	1. 955
400	4, 400	7. 100	3. 200	10. 300	2. 128	2. 573	. 995	. 115	5. 811	3. 754	1. 184	1. 955
500	5, 500	7. 800	3. 300	11. 100	2. 078	2. 565	. 993	. 115	5. 751	3. 762	1. 145	1. 955
600	6, 600	7. 800	3. 300	11. 100	2. 255	2. 795	1. 084	. 125	6. 259	3. 450	1. 135	1. 955
800	8, 800	7. 800	3. 300	11. 100	1. 994	2. 500	. 969	. 112	5. 575	3. 057	1. 090	1. 955
1,000	11, 000	7. 800	3. 300	11. 100	1. 801	2. 273	. 881	. 102	5. 057	2. 657	1. 064	1. 955
Screw press:												
25	275	0. 000	1. 900	1. 900	5. 684	6. 320	2. 446	. 283	14. 733	8. 014	2. 671	1. 878
50	550	1. 500	1. 900	3. 400	3. 529	4. 081	1. 578	. 182	9. 370	4. 085	2. 413	1. 878
100	1, 100	5. 000	1. 900	6. 900	2. 621	3. 162	1. 221	. 142	7. 146	3. 604	2. 096	. 977
150	1, 650	6. 500	2. 700	9. 200	2. 336	3. 161	1. 224	. 141	6. 862	3. 437	1. 910	. 977
200	2, 200	6. 500	2. 700	9. 200	2. 421	3. 003	1. 163	. 134	6. 721	3. 504	1. 781	. 977
300	3, 300	7. 100	3. 200	10. 300	2. 122	2. 602	1. 006	. 116	5. 846	3. 129	1. 653	. 977
400	4, 400	7. 100	3. 200	10. 300	1. 912	2. 360	. 913	. 106	5. 291	2. 798	1. 586	. 977
500	5, 500	7. 800	3. 300	11. 100	1. 925	2. 410	. 933	. 108	5. 376	2. 886	1. 548	. 977
600	6, 600	7. 800	3. 300	11. 100	2. 097	2. 639	1. 024	. 118	5. 878	2. 544	1. 537	. 977
800	8, 800	7. 800	3. 300	11. 100	1. 889	2. 399	. 931	. 108	5. 327	2. 277	1. 492	. 977

Type and size of mill	Operating—Continued												Total
	Water	Solvent	Meal bags	Maintenance and repairs	Laboratory services	Insurance on stocks	Salaries	General administration	Welfare risks	Working capital	Selling expense	Total	
Tons per day	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
Solvent:													
25	0. 271	1. 710	8. 460	1. 830	0. 140	0. 088	4. 050	0. 961	0. 950	1. 641	0. 646	40. 842	63. 507
50	. 225	1. 425	5. 584	1. 650	. 140	. 089	3. 902	1. 183	. 514	1. 466	. 998	27. 761	43. 920
100	. 191	1. 140	3. 722	1. 500	. 140	. 090	3. 623	1. 601	. 418	1. 486	1. 233	24. 033	39. 981
150	. 177	1. 026	3. 046	1. 410	. 383	. 090	3. 366	1. 986	. 380	1. 496	1. 351	22. 946	40. 421
200	. 168	. 912	2. 707	1. 350	. 333	. 090	3. 132	2. 338	. 357	1. 496	1. 409	22. 152	38. 982
300	. 145	. 798	2. 369	1. 260	. 377	. 089	2. 730	2. 942	. 313	1. 501	1. 468	21. 172	37. 968
400	. 144	. 741	2. 284	1. 200	. 329	. 089	2. 416	3. 413	. 290	1. 501	1. 468	20. 768	36. 879
500	. 139	. 684	2. 115	1. 170	. 300	. 089	2. 193	3. 751	. 284	1. 506	1. 527	20. 620	37. 471
600	. 136	. 684	2. 115	1. 140	. 323	. 089	2. 058	3. 956	. 262	1. 505	1. 527	20. 335	37. 694
800	. 128	. 627	2. 030	1. 080	. 288	. 089	2. 056	3. 967	. 239	1. 505	1. 586	19. 697	36. 372
1,000	. 123	. 570	1. 946	1. 050	. 267	. 089	2. 411	3. 447	. 227	1. 504	1. 644	18. 954	35. 111
Screw press:													
25	------	------	9. 000	2. 400	. 140	. 088	4. 050	. 961	. 496	1. 639	. 570	32. 214	48. 847
50	. 261	------	5. 940	2. 220	. 140	. 089	3. 902	1. 183	. 309	1. 465	. 945	24. 830	37. 600
100	. 083	------	3. 960	2. 070	. 140	. 090	3. 623	1. 601	. 278	1. 485	1. 195	21. 202	35. 248
150	. 075	------	3. 240	1. 980	. 350	. 090	3. 366	1. 986	. 263	1. 496	1. 320	20. 490	36. 552
200	. 070	------	2. 880	1. 950	. 300	. 090	3. 132	2. 338	. 259	1. 495	1. 383	20. 159	36. 080
300	. 064	------	2. 520	1. 860	. 344	. 089	2. 730	2. 942	. 229	1. 501	1. 445	19. 483	35. 629
400	. 060	------	2. 430	1. 800	. 296	. 089	2. 416	3. 413	. 204	1. 501	1. 445	19. 015	34. 606
500	. 058	------	2. 250	1. 770	. 318	. 089	2. 193	3. 751	. 201	1. 505	1. 508	19. 054	35. 530
600	. 056	------	2. 250	1. 740	. 290	. 089	2. 058	3. 956	. 181	1. 505	1. 508	18. 691	35. 669
800	. 052	------	2. 160	1. 680	. 255	. 089	2. 056	3. 967	. 169	1. 504	1. 570	18. 248	34. 675

[1] Production of bagged and bulk meal assumed to be in usual proportions.

TABLE 32.—*Estimated percentage change in processing cost for solvent mills by size of mill, 1952–53 season* [1]

Size of mill	Percentage increase in size of mill (from preceding mill)	Percentage change in cost (from preceding mill)	
		Decrease	Increase
Tons per day	*Percent*	*Percent*	*Percent*
25	0	0. 0	----------
50	100	30. 8	----------
100	100	9. 0	----------
150	50	----------	1. 1
200	33	3. 6	----------
300	50	2. 6	----------
400	33	2. 9	----------
500	25	----------	1. 6
600	20	----------	. 6
800	33	3. 5	----------
1,000	25	3. 5	----------

[1] Based on table 31. Excludes cost of beans.

doubling (50 to 100 tons per day) was accompanied by only a 9-percent decline; thereafter the declines were smaller.

The 500-ton mill had a higher cost (0.6 cent per bushel) than the 400-ton mill, due mainly to the increased cost of acquiring soybeans and increased labor cost which were not offset by large enough decreases in other costs, particularly plant cost (depreciation, interest, taxes, and insurance). The small increase in plant costs per bushel for the 500-ton mill was occasioned by the increase in bean-storage facilities from 80 days to 100 days' operation requirements. (Table 43.)

The 600-ton mill had a slightly higher cost (0.2 cent per bushel) than the 500-ton mill, due mainly to a slight upturn in plant cost at this level of operation, resulting from the addition of a boxcar dumper and associated equipment for unloading beans—an expensive piece of equipment as shown in table 45.

Third, the way in which major individual costs vary in proportion to total cost with changes in size of mill is significant. This variation is shown in table 33.

Individual costs, which *declined* most as a percentage of the total cost, were plant and labor. The decline in the cost of meal bags as a proportion of the total cost reflects the corresponding decline in the proportion of bagged to bulk meal with the increase in size of mill. Individual costs, which *increased* most rapidly as a percentage of the total cost were soybean acquisition and general administrative expense.

As shown in table 33, the percentage relationship of other individual costs to total cost remained relatively stable for different sizes of mills.

Check on Findings

The National Soybean Processors Association made available to the Special Crops Section costs from individual mills together with the volume of beans processed during the 1952–53 season. These data included all processing costs except markups by intermediary dealers on prices paid farmers for beans.

Figure 3 compares the cost-volume relationship, developed through use of model mills, with the similar relationship which was derived from the foregoing data from actual mills. With annual crushes between 550,000 and 11 million bushels, the relationship for model mills ranged from 2 to 10 cents lower per bushel than that for actual mills. This difference may be largely accounted for by the fact that, irrespective of size, mills in this study were assumed to run a 12-month season or 330 working days, and have no unutilized capacity. Actual mills, on the other hand, have unutilized capacity (table 1) ranging from approximately 50 percent of the total for small mills (100 tons and under per day) to 10 percent for large mills (350 tons and over per day).

Data made available by the National Soybean Processors Association, gave cost and volume of beans processed, but not the sizes of mills associated with different volumes of beans processed. Accordingly, data had to be obtained from other sources for checking the total cost (excluding beans) for different sizes of model mills. Data were made available for this purpose from 5 screw-press mills, ranging in size from 40 to 60 tons of daily capacity and averaging 46 tons. Operating at greatly reduced capacity in the 1952–53 season, these mills had an average processing cost of 40.5 cents per bushel, including an estimated 4 cents' acquisition charge. By comparison, the lower figure of 36 cents for the 50-ton model screw press appeared realistic, considering it was somewhat larger and was operating for a full season.

Data from three 100-ton screw-press mills, operating at greatly reduced capacity, had an average cost of 40 cents per bushel (including an estimated 6-cent acquisition charge). By comparison, the lower figure (30.2 cents) appeared reasonable for the 100-ton model screw-press mill considered as operating at full capacity.

For other model mills, the checks were indirect. That is, in the course of developing the models, persons familiar with large and small mills reviewed for reasonableness the input-size relationship of specific items, such as man-hours, investment, power, fuel oil, solvent loss, and maintenance and repair. Salaries, administrative expense, and transportation cost of soybeans were derived from data made available by the National Soybean Processors Association.

VARIATION OF COST WITH SIZE OF MILL, ASSUMING PRODUCTION OF BULK MEAL ONLY

In this study mills are compared in terms of net revenue (or loss) per bushel of beans processed and per dollar of investment, the usual proportion of bagged meal produced by different size mills

TABLE 33.—*Distribution of processing costs of solvent soybean oil mills, by size of mill, 1952–53 season* [1]

Size of mill	Soybeans processed annually	Processing cost per bushel of soybeans [2]	Distribution of processing cost												
			Soybean acquisition	Plant	Labor	Electric power	Fuel oil	Solvent	Meal bags	Maintenance and repairs	Salaries	General administration	Working capital	Selling expense	Other
Tons per day	*1,000 bushels*	*Cents*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
25	275	63. 51	3	33	23	3	6	3	13	3	6	1	3	1	2
50	550	43. 92	8	29	16	4	4	3	13	4	9	3	3	2	2
100	1, 100	39. 98	17	23	13	4	5	3	9	4	9	4	4	3	2
150	1, 650	40. 42	23	20	12	4	5	2	8	3	8	5	4	3	3
200	2, 200	38. 98	24	19	12	3	5	2	7	3	8	6	4	4	3
300	3, 300	37. 97	27	17	10	3	5	2	7	3	7	8	4	4	3
400	4, 400	36. 88	28	16	10	3	5	2	6	3	7	9	4	4	3
500	5, 500	37. 47	30	15	10	3	5	2	6	3	6	10	4	4	2
600	6, 600	37. 69	29	17	9	3	5	2	6	3	6	10	4	4	2
800	8, 800	36. 37	31	15	8	3	5	2	6	3	6	11	4	4	2
1,000	11, 000	35. 11	32	14	8	3	5	2	5	3	7	10	4	5	2

[1] Based on table 31.
[2] Excludes cost of soybeans.

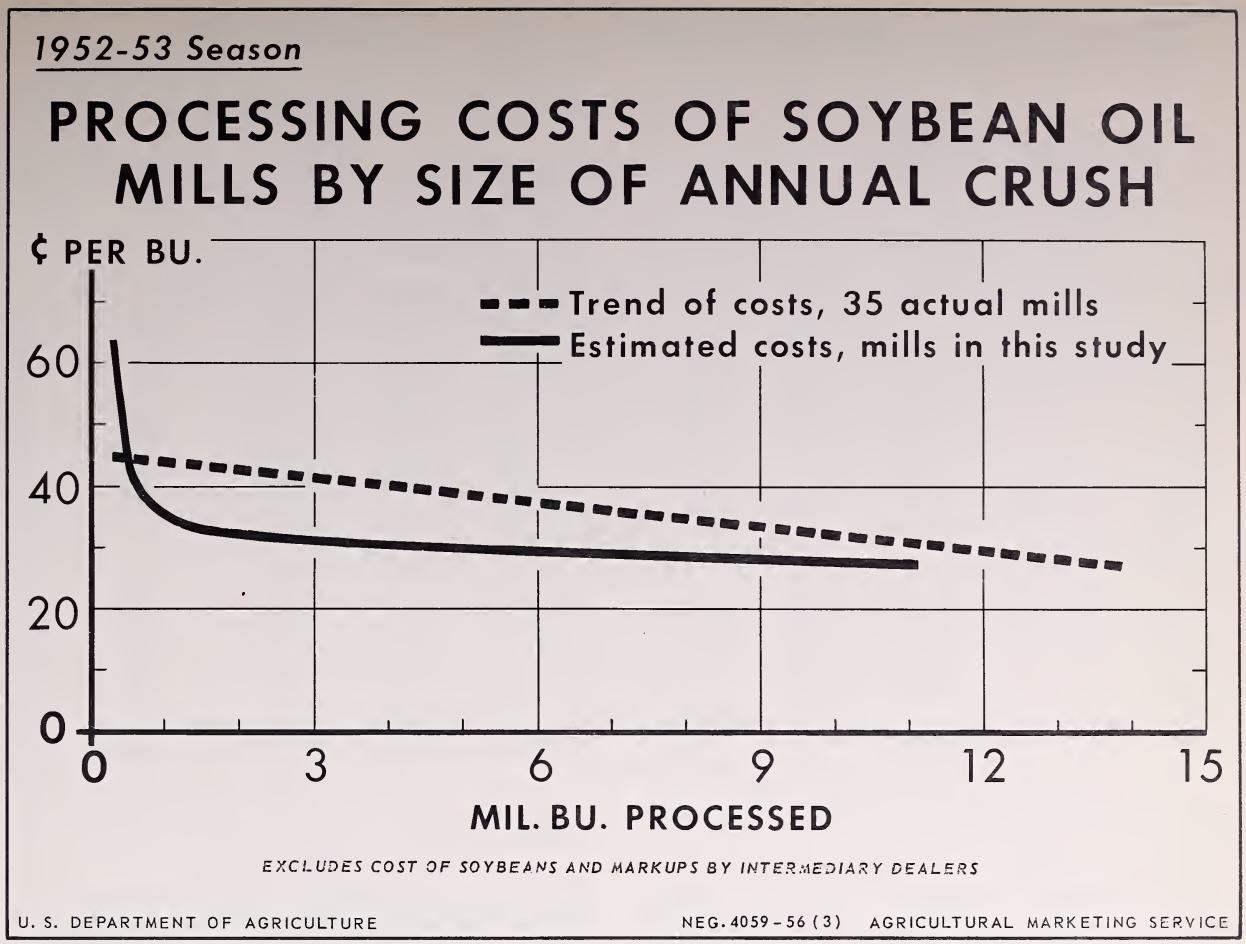


FIGURE 3.—Processing costs of soybean oil mills, by size of annual crush.

being assumed. The proportion decreases as the size of mill increases (table 7). As a consequence, variation in total cost with size of mill (table 31) is not wholly due to differences in size as such but partly to change in the proportion of bagged meal produced.

In line with customary comparisons, table 34 shows the variation of cost with size of mill under the assumption that all mills produced bulk meal only.

Table 34 shows the extent to which cost of different-size mills, when producing all bulk meal, is increased by producing their usual proportions of bagged meal. For example, the total processing cost of the 50-ton solvent mill producing bulk meal only was nearly 37 cents per ton as compared with nearly 44 cents when producing the usual proportion (66 percent) of bagged meal. The same principle applies to mills of other sizes in the table.

Larger mills can perform the meal-bagging operation more cheaply than smaller mills. But since the costs of meal bags are the same for all mills and the percentage of bagged meal declines rapidly with increasing size of mill, the decline in cost with size of mill is much greater than if all mills produced the same meal; either all bulk, all bagged, or the same proportion of both. For example, the total cost declined 4.1 cents per ton as the size of solvent mills was increased from 50 to 1,000 tons per day, with all sizes producing only bulk meal. This compared with a decline of 8.8 cents, with the 50-ton mill producing 66 percent bagged meal, and the 1,000-ton mill producing 23 percent bagged meal—the usual proportions for mills of these sizes.

VARIATION OF GROSS REVENUE WITH SIZE OF MILL

The next main question to be resolved is that of how gross revenue varies with change in size of mill under typical operating conditions. As previously stated (p. 1), mills receive approximately the same revenue per pound of oil but not per pound of meal. The larger the mill the greater its bulk-meal production as a percentage of the total, and bulk meal sells at a lower price than bagged meal. Also, the larger the mill the greater the proportion of meal which it must sell

TABLE 34.—*Comparison of estimated processing costs per bushel of soybeans for production of bulk meal only and production of both bagged and bulk meal, by type and size of mill, 1952–53 season*

Type and size of mill	Soybeans processed annually	Producing bulk meal					Producing usual proportion of bulk and bagged meal [2]	Proportion of bagged to bulk meal [3]	Increased cost for usual proportion of bagged meal
		Plant	Labor	Welfare risks	All other [1]	Total			
Tons per day	*1,000 bushels*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Percent*	*Cents*
Solvent:									
25	275	20. 624	11. 168	0. 768	19. 008	51. 568	63. 507	100	11. 939
50	550	12. 586	5. 661	. 446	18. 218	36. 911	43. 920	66	7. 009
100	1, 100	9. 071	4. 249	. 356	21. 475	35. 151	39. 981	44	4. 830
150	1, 650	8. 101	4. 488	. 362	23. 910	36. 861	40. 421	36	3. 560
200	2, 200	7. 500	4. 238	. 340	23. 762	35. 840	38. 982	32	3. 142
300	3, 300	6. 368	3. 701	. 297	24. 816	35. 182	37. 968	28	2. 786
400	4, 400	5. 739	3. 486	. 275	24. 740	34. 240	36. 879	27	2. 639
500	5, 500	5. 598	3. 480	. 268	25. 559	34. 905	37. 471	25	2. 566
600	6, 600	6. 200	3. 168	. 246	25. 608	35. 222	37. 694	25	2. 472
800	8, 800	5. 528	2. 767	. 223	25. 471	33. 989	36. 372	24	2. 383
1,000	11, 000	5. 017	2. 380	. 211	25. 224	32. 832	35. 111	23	2. 281
Screw press:									
25	275	14. 515	8. 014	. 496	16. 604	39. 629	48. 847	100	9. 218
50	550	9. 156	4. 085	. 309	17. 896	31. 446	37. 600	66	6. 154
100	1, 100	7. 131	2. 531	. 229	20. 260	30. 151	35. 248	44	5. 097
150	1, 650	6. 680	3. 096	. 247	22. 750	32. 773	36. 552	36	3. 779
200	2, 200	6. 585	3. 197	. 244	22. 716	32. 742	36. 080	32	3. 338
300	3, 300	5. 712	2. 840	. 216	23. 905	32. 673	35. 629	28	2. 956
400	4, 400	5. 213	2. 515	. 191	23. 883	31. 802	34. 606	27	2. 804
500	5, 500	5. 221	2. 586	. 187	24. 817	32. 811	35. 530	25	2. 719
600	6, 600	5. 816	2. 244	. 167	24. 816	33. 043	35. 669	25	2. 626
800	8, 800	5. 276	1. 967	. 154	24. 742	32. 139	34. 675	24	2. 536

[1] Includes all other costs as shown in table 31 excluding bags.

[2] From table 31.

[3] From table 7.

in the general market from which the f. o. b. mill returns are less than for meal which can be sold in the more favorable markets. The question thus arises as to how decreases in meal revenue with increases in size of mill compare with decreases in cost per bushel of beans.

THE PROBLEM OF PRICES

Oil prices were obtained from regularly published sources. As variations in the price of oil, among different oil markets, are relatively small, it was assumed that the 1952–53 average price of 12.1 cents per pound of oil, f. o. b. midwestern mills, was approximately the price received by any mill under typical operating conditions.

Meal, however, presented a formidable problem. Mill returns from meal vary between the two forms of meal, bagged and bulk; and they further vary, depending on whether the meal is produced by solvent or screw-press mill and also on whether the meal is shipped by truck or rail. "Trucked" and "rail shipped" are here used interchangeably with "local and wholesale." Prices of these forms of meal vary widely among different markets. Also, meal may be sold by any individual mill in widely different markets. No information was directly available on meal returns for the industry as a whole.

As a consequence the problem of calculating meal returns (f. o. b. mill) per bushel of beans for the mills in this study fell into two main stages. First was that of estimating an average price (1952–53 season) per ton for each form of meal for the industry as a whole. These estimates are shown in table 35. The second problem was that of calculating the value of meal for each mill in this study. This was done through weighting the average prices of bulk and bagged meal shipped by rail and truck, by the quantities of each of these meals produced by each mill. These estimates are shown in table 37.

TABLE 35.—*Estimated average f. o. b. mill prices per ton of soybean meal for solvent and screw-press mills, 1952–53 season* [1]

Form of meal and type of shipment	Solvent	Screw press
Bagged:		
Rail-shipped	$75	$77
Trucked	80	82
Bulk:		
Rail-shipped	70	72
Trucked	75	77

[1] Estimates based on meal shipments of 200-ton-per-day mills which are typical of the industry. (See p. 29.)

Solvent Bagged Meal

The main problem here was how to estimate the 1952–53 average price of solvent bagged meal, when shipped by rail or truck, for the industry as a whole.

Rail-Shipped Bagged Meal. The average mill price of rail-shipped solvent meal (44 percent protein) was estimated for one size of mill, namely 200 tons per day. This choice was made because more mills were approximately this size than any other, and in various characteristics this size mill approximated the average for the industry. In this estimate the following major steps were taken. First, three mill points were selected: Decatur, Ill., Fort Dodge, Iowa, and Decatur, Ind. Second, the total rail shipments of the 200-ton mill in each State were distributed among different terminal markets in approximately the same proportions as the 1950 total rail shipments from that State. Third, with reference to each of the markets shown in table 36, enough points of origin of bean shipments were selected to account for the meal shipped to that market. In no county ("point of origin") was the mill assumed to obtain more than one-third of the total beans produced. This restriction was in line with the experience of bean suppliers selling to many buyers. Fourth, using published tariff schedules, we selected routings and calculated freight costs for bean and meal shipments in such a way as to take maximum advantage of transit privileges. Fifth, the freight costs were subtracted from gross meal receipts per ton to get the following average values of bagged meal shipped by rail from the following mill points:

Mill location	Estimated average value per ton of rail-shipped bagged meal, 1952–53 season
	(Dollars)
Decatur, Ill	72. 89
Fort Dodge, Iowa	77. 22
Decatur, Ind	76. 10

For the following reasons we assumed that these calculated prices were reasonably typical for rail-shipped bagged meal for mills in the western, central, and eastern sections of the Soybean Belt. (1) The pricing points were centrally located in their respective sections of the Soybean Belt and were also good transit points. (2) There was no appreciable difference between the 1952–53 Decatur, Ill., quoted price and the calculated price. Since the "Decatur, Ill., price" is generally regarded as fairly typical for meal sold in Illinois, the other calculated prices (Fort Dodge, Iowa, and Decatur, Ind.) should be typical for the western (Iowa and Minnesota) and eastern (Indiana and Ohio) sections of the Soybean Belt as the same method was used in calculating all three prices. Finally (3), the differentials between the above-calculated prices are in line with those which persons familiar with soybean oil mill operations claim to prevail between the eastern, central, and western sections of the Soybean Belt. That is, mills in the western section are generally said to have approximately $4 per ton advantage over the central section, and mills in the eastern section to have approximately a $3 advantage over those of the central section.

The average price of approximately $75 per ton for rail-shipped bagged meal for the Soybean Belt as a whole was estimated by weighting the sectional prices (shown above) by the quantity of meal shipped by rail in each section in 1950, the latest year for which data were available.

Table 36.—*Estimated percentage distribution of Illinois, Iowa, and Indiana rail shipments of soybean meal among terminal markets, 1948–52 average*

Meal market	Price of bagged soybean meal per ton [1]	Distribution of rail shipments of soybean meal [2]		
		Illinois	Indiana	Iowa
	Dollars	*Percent*	*Percent*	*Percent*
Burlington, Vt	[3] 86. 60	2	6	------
Buffalo, N. Y	83. 95	10	31	------
Philadelphia, Pa	[4] 88. 30	3	7	------
Cincinnati, Ohio	79. 70	11	28	------
Indianapolis, Ind	82. 36	6	10	------
Chicago, Ill	80. 05	21	1	------
Wilmington, Del	[4] 88. 30	2	6	------
Memphis, Tenn	76. 70	6	2	------
Louisville, Ky	79. 90	2	2	------
Lansing, Mich	[5] 80. 05	3	------	------
Milwaukee, Wis	80. 13	4	------	3
Minneapolis, Minn	79. 80	2	------	17
Des Moines, Iowa	86. 88	3	------	14
Wichita, Kans	89. 65	1	------	5
Kansas City, Mo	79. 30	7	------	10
Omaha, Nebr	86. 74	------	------	15
Dallas, Tex	87. 65	3	------	4
Denver, Colo	90. 85	------	------	4
Ogden, Utah	97. 41	------	------	2
Seattle, Wash	98. 28	------	------	4
San Francisco, Calif	97. 35	------	------	7

[1] Estimate of average prices for 1952–53 season as reported by AMS Market News and compiled from Feedstuffs.

[2] Computed from Carload Waybill Analyses (based on 1-percent sample of carload waybills), State-to-State Distribution of Products of Agriculture, Bureau of Transport Economics and Statistics, Interstate Commerce Commission. Percentages relate to shipments to indicated States only, not to cities. Only shipments to major markets included.

[3] Average price at Boston, Mass., used as no prices available for Vermont.

[4] Average price at New York, N. Y. used as no prices available for Pennsylvania and Delaware.

[5] Average price at Chicago, Ill., used as no prices available for Michigan.

Truck-Shipped Bagged Meal. It did not appear reasonable that trucked deliveries of meal, originating at mills within the western, central, or eastern sections of the Soybean Belt, would on the average terminate in markets outside the sections. More specifically, it was assumed that meal, picked up by truck at mills in the western section (Iowa and Minnesota), would usually be delivered to some point within this section rather than to such outside points as Dallas, Denver, Salt Lake City, and the like. The same assumption applies to each of the other sections.

As Des Moines, Iowa, is not far from the center of the western section of the Soybean Belt, the Des Moines price ($86.88 per ton) was assumed as fairly representative of the f. o. b. (mill) value of trucked meal for mills in the western section. Similarly the Decatur, Ill., price ($72.89 per ton) was used for the central section, and the Indianapolis price ($82.36 per ton) was used for the eastern section.

An average price of approximately $80 per ton for truck-shipped bagged meal throughout the industry was then obtained by weighting the above prices by the estimated tons of meal shipped by truck in 1950 in the corresponding sections of the Soybean Belt.

Price Differential Between Different Forms of Meal

The industrywide average f. o. b. prices for other meal (bulk solvent and all screw-press) were determined by applying price differentials between bagged and bulk meal and between solvent and screw-press meal.

The U. S. Department of Agriculture maintains a record of prices of bulk and bagged meal at Decatur, Ill. In the 1952–53 season, bagged meal sold for approximately $5 more per ton than bulk meal. This figure is not peculiar to the 1952–53 season as it is in line with the trend from 1949 on, except for the 1950–51 season when quoted prices were misleading because the form of meal in that season was altered in form by the addition of crushed corn, concentrated minerals, and other ingredients, and was priced as mixed feed.

The price spread between solvent and screw-press meal varied appreciably from year to year in the various terminal markets. For the 1952–53 season, screw-press meal averaged $2 more per ton than solvent meal. This difference was used in estimating the prices shown in table 35.

VARIATION OF MEAL REVENUE PER BUSHEL OF BEANS WITH SIZE OF MILL

The proportions of bulk and bagged meal for mills of different size are shown in table 7.

The proportions of trucked (or local) and rail-shipped (wholesale) meal were assumed to be approximately the same as the proportions of truck- and rail-delivered beans. (The latter were shown in table 11.) Regardless of whether meal is sold in the local or general market, operators prefer, if possible, to get local beans; and regardless of the source of beans, they prefer to sell meal locally. So far as compatible with this objective, they strive to keep their truck and rail meal shipments so matched with their truck-delivered and rail-delivered beans as to take maximum advantage of their railroad transit privileges.

The average meal revenue (f. o. b. mill) per bushel of beans for different sizes of mills in this study was then calculated by weighting the prices of rail-shipped meal by the volume of such meal and the prices of truck-shipped meal by its volume. These estimates are shown in table 37.

CHECK ON MEAL-REVENUE ESTIMATES

If all mills are assumed to operate a full season, the relationship (table 37) between size of mill and f. o. b. meal returns appears to be in line with what persons familiar with the soybean oil mill industry would expect. Data for quantitative checks were not available for medium and large mills but were available for small mills. Five screw-press mills, ranging in size from 40 to 60 tons daily capacity and averaging 46 tons, had an average 1952–53 meal return of $85.30 per ton of meal. This was 17 cents more per bushel of beans processed than the estimated return for the 50-ton screw-press mill in this study. This 50-ton mill was somewhat larger than the 5 "check" mills and would probably realize a somewhat lower meal return for this reason alone; but, more important, it was assumed to operate a full season, whereas the 5 "check" mills operated only when meal and oil price fluctuations were most favorable, their total crushing days being equivalent to approximately a 6-month season. Operating in this way, they were able to achieve an appreciably higher meal return than if they had run continuously, but they also experienced correspondingly higher operating costs.

NET REVENUE PER BUSHEL OF BEANS PROCESSED AND SIZE OF MILL

While cost declined appreciably with increases in the sizes of mills, total (meal) revenue declined by approximately the same amount. As a consequence, there was no appreciable relationship between size of mills and net revenues (or losses) per bushel of beans processed (table 38).

As indicated in table 39, the spread between the value of soybean products per bushel of beans and prices received by farmers for beans was less in the 1952–53 season than in any other operating season from 1949–50 through 1953–54. These gross margins are based on the Decatur price of soybean oil and bulk meal which were the only ones available for these seasons.

These margins (table 39) are less than the actual ones for the industry as a whole for two reasons. They (1) are based on the Decatur, Ill., price of

TABLE 37.—*Estimated value of soybean products per bushel of soybeans processed for solvent and screw-press mills, by size of mill, 1952–53 season*

Type and size of mill	Soybeans processed annually	Products				
		Soybean oil		Soybean meal		Total value per bushel
		Price per pound [1]	Value per bushel [2]	Price per ton [3]	Value per bushel [4]	
Tons per day	*1,000 bushels*					
Solvent:		*Cents*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
25	275	12.1	1.331	79.50	1.868	3.199
50	550	12.1	1.331	76.30	1.793	3.124
100	1,100	12.1	1.331	74.20	1.744	3.075
150	1,650	12.1	1.331	73.30	1.723	3.054
200	2,200	12.1	1.331	72.85	1.712	3.043
300	3,300	12.1	1.331	72.40	1.701	3.032
400	4,400	12.1	1.331	72.35	1.700	3.031
500	5,500	12.1	1.331	72.00	1.692	3.023
600	6,600	12.1	1.331	72.00	1.692	3.023
800	8,800	12.1	1.331	71.70	1.685	3.016
1,000	11,000	12.1	1.331	71.40	1.678	3.009
Screw press:						
25	275	12.1	1.089	81.50	2.038	3.127
50	550	12.1	1.089	78.30	1.958	3.047
100	1,100	12.1	1.089	76.20	1.905	2.994
150	1,650	12.1	1.089	75.30	1.883	2.972
200	2,200	12.1	1.089	74.85	1.871	2.960
300	3,300	12.1	1.089	74.40	1.860	2.949
400	4,400	12.1	1.089	74.35	1.859	2.948
500	5,500	12.1	1.089	74.00	1.850	2.939
600	6,600	12.1	1.089	74.00	1.850	2.939
800	8,800	12.1	1.089	73.70	1.843	2.932

[1] 1952–53 average price of soybean oil, f. o. b. midwestern mills.

[2] Based on average 1951 and 1952 oil yields of 11 and 9 pounds per bushel for solvent and screw-press mills, respectively, as estimated from Bureau of Census reports.

[3] Based on estimated 1952–53 average meal prices of $75 and $70 per ton received by solvent mills for bagged and bulk meal sold in proportions shown in table 7. Price differential of $2 more per ton assumed received by screw-press mills for 41 percent protein meal than by solvent mills producing 44 percent protein meal. Mills assumed to receive $5 more per ton for meal shipped by truck than rail (table *35*). Proportions of meal shipped by rail approximately the same as soybeans received by rail shown in table *11*. All bulk meal was shipped by rail.

[4] Based on average 1951 and 1952 meal yields of 47 and 50 pounds per bushel for solvent and screw-press mills, as estimated from Bureau of Census reports.

bulk meal, which is less than the average for the industry, as previously noted. For example, the 1952–53 Decatur value of $1.61 of bulk meal per bushel of beans was equivalent to $67.58 per ton of bulk meal, whereas the average estimated for the industry for rail-shipped meal was $70 per ton (table 35). This compared with $75 for bagged meal. Second, the margins do not take account of the proportions of higher valued bagged meal (trucked and rail-shipped) that are produced by various mills. According to table 7, the average proportions of bulk and bagged meal for the 200-ton mill were 65 and 35 percent, respectively.

Adjusting the 1952–53 Decatur price for these factors gives a meal return of $1.71 per bushel of beans for the average 200-ton solvent mill instead of $1.61 (table 39). (Meal returns for other sizes of mills in this study would likewise depend on the bagged-bulk meal proportions shown in table 7 and the amount of meal shipped by rail and truck.) Applying these correction factors to the meal values in table 39 for other years, while assuming 1952–53 processing costs and using industry average oil and meal yields for both solvent and screw-press mills, the net margins for the 200-ton solvent mill in this study are shown in the following tabulation. (The loss of 9 cents in the 1952 crop-year is 1.3 cents greater than that shown in table 39 where the actual yield of the solvent process was used instead of the industry average of both solvent and screw-press processes.)

Operating season	*Net margin per bushel (cents)*
1949–50	27
1950–51	48
1951–52	6
1952–53	−9
1953–54	26

In general, prices of production factors were not appreciably different in the 1951–52 and 1953–54 operating seasons from those of the 1952–53 season, but the price of meal was much higher. In earlier years, prices of production factors were lower.

TABLE 38.—*Calculated costs and returns of solvent soybean oil mills, by size of mill, 1951–52 through 1953–54 operating seasons*

Size of mill	Soybeans processed annually	Investment per bushel [1]	1951–52				1952–53				1953–54				Average	
			Cost per bushel [2]	Revenue per bushel		Returns per dollar of investment [4]	Cost per bushel [2]	Total revenue per bushel [3]	Loss		Cost per bushel [2]	Revenue per bushel		Return per dollar of investment [4]	Net revenue per bushel	Return per dollar of investment [4]
				Total [3]	Net				Per bushel	Per dollar of investment [4]		Total [3]	Net			
Tons per day	*1,000 bushels*	*Dollars*	*Dollars*	*Dollars*	*Cents*	*Cents*	*Dollars*	*Dollars*	*Cents*	*Cents*	*Dollars*	*Dollars*	*Cents*	*Cents*	*Cents*	*Cents*
25	275	2. 218	3. 375	3. 321	−5. 4	−2. 4	3. 365	3. 199	16. 6	7. 5	3. 385	3. 541	15. 6	7. 0	−2. 1	−0. 9
50	550	1. 375	3. 179	3. 248	6. 9	5. 0	3. 169	3. 124	4. 5	3. 3	3. 189	3. 467	27. 8	20. 2	10. 1	7. 3
100	1, 100	. 987	3. 140	3. 200	6. 0	6. 1	3. 130	3. 075	5. 5	5. 6	3. 150	3. 419	26. 9	27. 3	9. 1	9. 2
150	1, 650	. 910	3. 144	3. 179	3. 5	3. 8	3. 134	3. 054	8. 0	8. 8	3. 154	3. 398	24. 4	26. 8	6. 6	7. 3
200	2, 200	. 843	3. 130	3. 168	3. 8	4. 5	3. 120	3. 043	7. 7	9. 1	3. 140	3. 388	24. 8	29. 4	7. 0	8. 3
300	3, 300	. 717	3. 120	3. 158	3. 8	5. 3	3. 110	3. 032	7. 8	10. 9	3. 130	3. 378	24. 8	34. 6	6. 9	9. 6
400	4, 400	. 643	3. 109	3. 157	4. 8	7. 5	3. 099	3. 031	6. 8	10. 6	3. 119	3. 377	25. 8	40. 1	7. 9	12. 3
500	5, 500	. 641	3. 115	3. 149	3. 4	5. 3	3. 105	3. 023	8. 2	12. 8	3. 125	3. 368	24. 3	37. 9	6. 5	10. 1
600	6, 600	. 699	3. 117	3. 149	3. 2	4. 6	3. 107	3. 023	8. 4	12. 0	3. 127	3. 368	24. 1	34. 5	6. 3	9. 0
800	8, 800	. 625	3. 104	3. 142	3. 8	6. 1	3. 094	3. 016	7. 8	12. 5	3. 114	3. 361	24. 7	39. 5	6. 9	11. 0
1,000	11, 000	. 568	3. 091	3. 135	4. 4	7. 7	3. 081	3. 009	7. 2	12. 7	3. 101	3. 355	25. 4	44. 7	7. 5	13. 2

[1] From table 84.

[2] Based on processing costs as shown in table 31 and prices received by farmers for beans as shown in table 8.

[3] From table 37 for 1952–53 season. Adjusted as described on page 31 for 1951–52 and 1953–54 operating seasons.

[4] After all cost, including interest on both fixed and working capital, whether owned or borrowed.

TABLE 39.—*Average United States value of soybeans and soybean products per bushel of soybeans processed, 1949–50 through 1953–54 operating seasons*

Operating season	Soybeans processed [1]	Price of soybeans received by farmers [2]	Products							Spread between price received by farmers for soybeans and value of oil and meal per bushel of soybeans processed
			Yield per bushel [1]		Price per pound [3]		Value per bushel			
			Oil	Meal	Oil	Meal	Oil	Meal	Total	
	1,000 bushels	*Dollars*	*Pounds*	*Pounds*	*Cents*	*Cents*	*Dollars*	*Dollars*	*Dollars*	*Cents*
1949–50	195, 533	2. 17	9. 9	46. 9	12. 3	3. 215	1. 22	1. 51	2. 73	56
1950–51	251, 862	2. 47	9. 7	46. 8	17. 8	3. 223	1. 73	1. 51	3. 24	77
1951–52	242, 842	2. 73	10. 0	46. 7	11. 3	4. 168	1. 13	1. 95	3. 08	35
1952–53	233, 880	2. 72	10. 8	47. 5	12. 1	3. 379	1. 31	1. 61	2. 92	20
1953–54	[4]218, 291	2. 73	[4]10. 8	[4] 46. 3	13. 5	3. 932	1. 46	1. 82	3. 28	55

[1] Compiled from reports of the Bureau of the Census.
[2] BAE, Farm Production, Farm Disposition and Value of Principal Crops, 1950 through 1954.
[3] Oil prices f. o. b. midwestern mills; meal prices for bulk meal, Decatur (41 percent protein before July 1950, 44 percent protein thereafter).
[4] Preliminary.

The spread between the value of soybean products per bushel of beans and prices received by farmers for beans was not sufficient to enable any mill in this study to meet cost in the 1952–53 season (table 39). The like is not true, however, for the preceding or the following season, assuming that processing costs (including markup on beans by country elevators and other intermediary dealers) were approximately the same for each of these three seasons. In these terms, the average spread between the value of soybean products and soybean prices received by farmers for the 1951–52 through the 1953–54 operating seasons was enough to enable all mills in this study to show net returns per bushel of beans processed and per dollar of investment (table 38).

RETURNS TO GROWERS AND SIZE OF MILLS

The major question of this study may now be resolved: Assuming mills process beans into first products only, to what extent, if any, may industrywide change in the size of mills benefit farmers in the form of higher prices for beans?

In considering this question, we may disregard mills of 100 tons per day and under in size. Such small mills account for approximately 4 percent of all beans processed in the Soybean Belt (table 1)—a quantity too small to have any appreciable influence on the level of prices paid farmers for soybeans.

As previously shown, relatively small mills are usually associated with meal-market advantages. As long as such a mill can sell a major proportion of its meal locally, it is in a strong position with respect to a large mill that has lower costs but also lower returns because it must sell more of its meal in the general market.

It is mainly because of these differences in the meal markets of different size mills that meal (and hence total) revenue and cost declined in approximately the same amounts with increases in size of mill.

Despite this nearly uniform net revenue (or loss) per bushel, the larger the mill the smaller its investment per bushel as shown in table 38. Hence, the greater was its return per dollar of investment. (These returns are shown as a smooth curve in fig. 4.) Consequently, a larger mill enjoyed a differential profit which could be used to bid up the price of beans until its returns per dollar of investment fell to that of the smaller mill. The higher the basic profit level on which the industry is competing the greater is this differential ability of the bigger mill to pay more for beans.

As calculated in this study with data for 3 years (1951–52 through 1953–54 seasons) the profit differential between a 150-ton and a 1,000-ton mill was 4.5 cents per dollar of investment, which is equivalent to only 2.4 cents per bushel of beans—the amount by which the 1,000-ton mill could bid up the price of beans if it used all its differential profit for this purpose. Using the 150-ton mill as a base, the last column of table 40 shows the approximate extents to which successively larger mills could bid up the price of beans paid farmers.

Compared with the actual industry of various sizes of mills, the extent to which an industry of only 1,000-ton mills or over could raise the price of soybeans would be substantially less than 2.4 cents per bushel.

While no reorganization of the industry into fewer but bigger mills could raise the price of beans appreciably, any reorganization of the industry into a larger number of smaller mills would result in either a higher price for soybean meal or

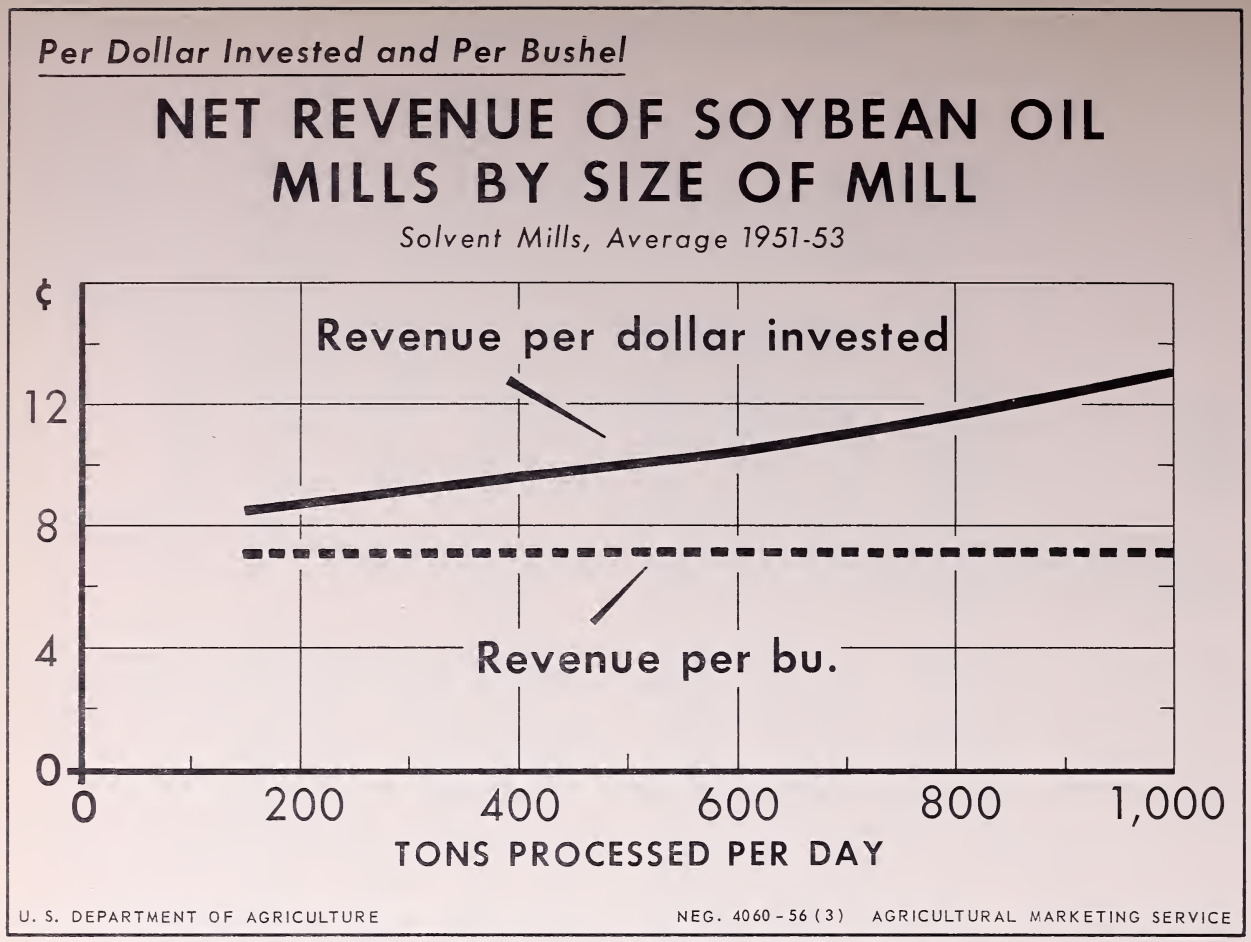


FIGURE 4.—Net revenue of soybean oil mills, by size of mill.

TABLE 40.—*Profit of solvent soybean oil mills, by size of mill, 1951–52 through 1953–54 seasons*

Size of mill	Investment per bushel [1]	Profit per dollar of investment [2]	Profit differential (base=150-ton mill)	
			Per dollar of investment	On investment per bushel of beans [3]
Tons per day	*Cents*	*Cents*	*Cents*	*Cents*
150	81. 9	8. 5		
200	80. 3	8. 7	0. 2	0. 2
300	77. 0	9. 1	. 6	. 5
400	73. 7	9. 5	1. 0	. 7
500	70. 4	9. 9	1. 4	1. 0
600	67. 0	10. 4	1. 9	1. 3
800	60. 4	11. 6	3. 1	1. 9
1,000	53. 8	13. 0	4. 5	2. 4

[1] From straight line fitted to data in table 38.

[2] From figure 4.

[3] Investment per bushel times differential profit per dollar of investment.

$$\frac{\text{differential profit}}{100}$$

The figures in this column represent the amounts by which individual mills could bid up the price of beans if all differential profit were used for that purpose.

a lower price for soybeans, or both. Soybean production is highly concentrated relative to the area of the general market for soybean meal where the f. o. b.-mill price is lower than the local market price. To increase the number of small mills with advantages equivalent to those of present small mills would require extensive additional local markets. Such expansion of local markets are not possible. Local meal demand in the soybean belt is already being largely supplied by local mills.

COMPARATIVE ECONOMIES OF SMALL SOLVENT AND SCREW-PRESS MILLS

A subordinate purpose of this study was to determine the approximate point in the scale of operations at which solvent mills become more economical than screw-press mills.

The screw-press mill was definitely more economical than the solvent mill at 25 tons per day, primarily because of relatively lower investment and labor requirements per bushel of crushing capacity (table 41). However, primarily because of the relatively faster decline in capital and labor

TABLE 41.—*Advantage in returns arising from shifting from screw-press to solvent mills, by size of mill, 1952–53 operating season*

Size of mill	Soybeans processed annually	Investment per bushel [1]		Loss per bushel [2]		Advantage to solvent mills per bushel	Loss per dollar of investment		Advantage to solvent mills per dollar of investment
		Screw press	Solvent	Screw press	Solvent		Screw press	Solvent	
Tons per day	*1,000 bushels*	*Dollars*	*Dollars*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
25	275	1. 580	2. 218	9. 1	16. 6	—7. 5	5. 8	7. 5	—1. 7
50	550	1. 020	1. 375	5. 9	4. 5	1. 4	5. 8	3. 3	2. 5
100	1, 100	. 791	. 987	8. 8	5. 5	3. 3	11. 1	5. 6	5. 5
150	1, 650	. 790	. 910	12. 3	8. 0	4. 3	15. 6	8. 8	6. 8
200	2, 200	. 751	. 843	13. 1	7. 7	5. 4	17. 4	9. 1	8. 3
300	3, 300	. 650	. 717	13. 7	7. 8	5. 9	21. 1	10. 9	10. 2
400	4, 400	. 590	. 643	12. 8	6. 8	6. 0	21. 7	10. 6	11. 1
500	5, 500	. 603	. 641	14. 6	8. 2	6. 4	24. 2	12. 8	11. 4
600	6, 600	. 660	. 699	14. 8	8. 4	6. 4	22. 4	12. 0	10. 4
800	8, 800	.·600	. 625	14. 5	7. 8	6. 7	24. 2	12. 5	11. 7

[1] Based on table 84.
[2] Based on tables 31 and 37, assuming mills operate at average of data used in this study.

requirements, solvent mills became more economical than screw-press mills at approximately 50 tons of crushing capacity per day, the advantage of the solvent mill at this point being over 1 cent per bushel and 2.5 cents per dollar of investment. This advantage increased to 5 cents per bushel and 8.3 cents per dollar of investment as the size of mill increased to 200 tons per day. Beyond this point the advantage per bushel remained relatively stable, solvent costs being approximately 2 cents higher per bushel and gross revenue approximately 8 cents higher. But investment requirements per bushel of beans declined more rapidly for solvent mills than for screw press, particularly up to 400 tons per day. As a consequence, the larger the mill the greater the advantage of shifting to solvent mills even though the advantage per bushel remains the same. This would appear to explain largely why the rapid shift of the industry from screw-press to solvent mills in recent years has been restricted almost entirely to mills of 200 tons per day and over.

V. APPENDIX: PLANT DESIGNS AND INVESTMENT REQUIREMENTS

Plant costs (depreciation, interest, insurance, and property taxes) of all solvent and screw-press soybean oil mills appearing in this study were placed on a comparable basis by designing new mills on paper and estimating their capital requirements. The exact forms of the mill designs which were developed depended largely on three considerations: They should (1) be practical; (2) resemble actual operating mills; and (3) fit the purposes of the study and contribute to solution of the central problems of the study.

METHODS OF DETERMINING INVESTMENT REQUIREMENTS

Estimates of initial investment requirements of mills were based on manufacturers' prices of equipment and building materials, freight costs, and estimated installation or construction charges. Actual or estimated freight charges on equipment and materials were calculated from their point of manufacture to three installation points: Indianapolis, Ind., Waterloo, Iowa, and Memphis, Tenn. However, in the tables in the appendix, costs for all three installation points are shown only when they differ appreciably, and total investment costs are shown only on the basis of costs at Indianapolis.

For most of the different departments of the mills, estimates of investment requirements were carried out according to several distinct operations. In other departments some of the steps were omitted or modifications of the general procedure were made. Some of these modifications are described. The exact estimating procedure in all cases depended upon the complexity of the particular mill facility being estimated, its total cost and importance, and the amount of data available on physical requirements and costs.

The techniques used are described and discussed under the following heads: (1) Drawings, (2) selection of equipment, (3) machinery costs, (4) materials costs, (5) equipment installation costs, (6) freight charges, (7) classification of materials and equipment for tabulation, (8) cost units and cost groups, and (9) general principles.

DRAWINGS

From drawings of equipment layouts department by department, together with manufactur-

ing prices and equipment specifications, estimates were made of investment requirements for each mill in this study. (These estimates included installation charges.) The principles of mill designs are shown in figures 5 through 8, 14 through 17, 29 through 31, and 38 through 40. Drawings are not shown of all departments inasmuch as the drawings illustrate general principles only. Also, most of the departments not shown (such as boilerhouse, machine shop, and storeroom) were not designed in as great detail as were the processing departments.

SELECTION OF EQUIPMENT

Generally speaking, an attempt was made to incorporate patterns of design and to select machinery found in actual mills. Both of these principles allowed a good deal of latitude. One other principle followed was that quantities and sizes of equipment would be selected to handle beans at a rate of at least 1¼ times the normal processing rates set up for the mills (table 2).

MACHINERY COSTS

Most machinery costs were quotations received direct from manufacturers' representatives. Published cost data from many sources were used when they were applicable and sufficiently accurate.

A most valuable technique used to fill in missing cost data was plotting the relationship among costs of similar items, whereby the plot of cost versus size in selected units will form a straight, or nearly straight, line on log-log graph paper. This relationship is well known and much used by cost estimators. Often costs were estimated by this technique for equipment of sizes other than those for which data were available. In some cases, to save time, detailed cost estimates were prepared of particular facilities for a few sizes of mills, and costs for other sizes of mills were estimated from log-log graphs of the detailed data. This technique was also useful for checking the reasonableness of data from several different sources or of estimates prepared from incomplete data.

MATERIALS COSTS

Prices, applied to calculated quantities of construction materials came from many sources. Usually materials were priced by unit costs in dollars or cents per pound, per square foot, or per cubic yard. Because materials unit costs are much used by cost estimators, published data were particularly helpful for pricing materials. Whether taken from published data or put together for this particular study, the materials unit costs included allowances for waste and had separate figures for labor, including contractor's overhead and profit. All major construction work was assumed to be carried out by a general contractor, although engineering and machinery installation were assumed to be done by the owner.

EQUIPMENT INSTALLATION COSTS

Cost for installing equipment varies depending upon the size, shape, and complexity of the equipment and consequent degree of skill and special equipment required, the degree of assembly at the factory, and various local conditions. In order to simplify and speed the work, a factor was made up to multiply by the equipment cost in order to estimate installation and ancillary costs. It was applied to nearly all equipment in the mills.

This procedure obviously results in estimates that are too high for some items of equipment and too low for some others, but the overall estimate is believed to be approximately correct. The makeup of the multiplier used is shown below.

Certain overhead costs normally apply to the direct labor cost, and others may conveniently be expressed as percentages of direct labor. The markup to apply to direct labor costs was estimated as follows:

	Percent
Federal old-age insurance (maximum)	1. 5
Workman's compensation insurance (approximate average)	3. 2
Federal and State unemployment compensation (maximum)	3. 0
Total payroll taxes and insurance	7. 7
Field supervision	12. 5
Office expense (materials and labor)	10. 0
Temporary structures and utility connections	2. 5
Tools, minor equipment, and supplies	2. 5
Equipment rental	7. 5
Cleaning-up job	2. 5
Total direct labor markup	45. 2

This total was rounded off to 45 percent of direct labor.

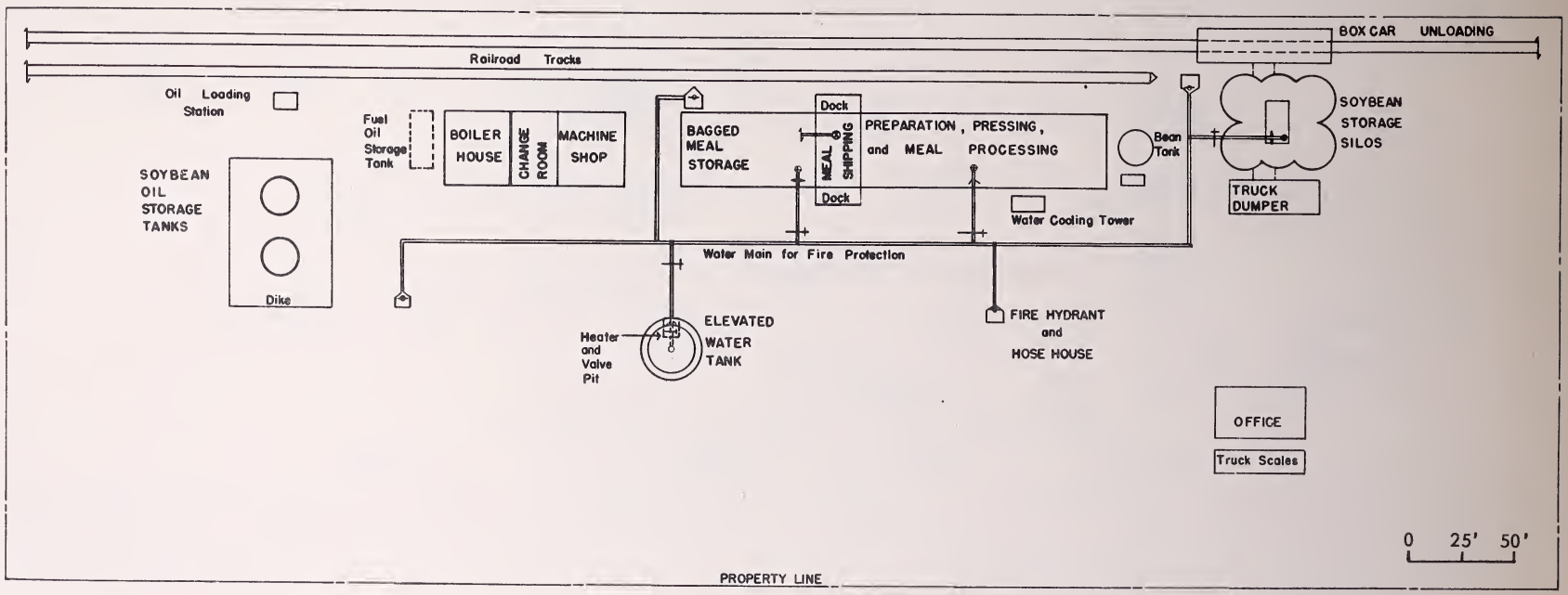
Based on $100 of equipment, the installation and complementary costs were estimated as follows:

Direct labor	$15. 00	
Direct labor markup (0.45x15.00)	6. 75	
Total installation		$21. 75
Purchasing, and coordination engineering	$3. 00	
Cartage	1. 00	
Insurance (fire and extended coverage on uncompleted mill, plus public liability)	1. 00	
Total other costs		5. 00
Total installation and other costs		26. 75

This figure of $26.75 was rounded to $27, and was applied by multiplying equipment costs by the factor of 1.27.

FREIGHT CHARGES

Where sales of equipment are not commonly made on the basis of delivery to destination, freight charges were obtained from manufacturers, or were estimated, and delivered costs of equipment to three cities were calculated: Indianapolis, Ind., Waterloo, Iowa, and Memphis, Tenn.



U. S. DEPARTMENT OF AGRICULTURE NEG. 4085-56 (4) AGRICULTURAL MARKETING SERVICE

FIGURE 5.—Property layout for a 4-press (100 tons per day) screw-press soybean oil mill. Fire protection features are shown also. (Property layouts for 1- and 2-press mills are similar.)

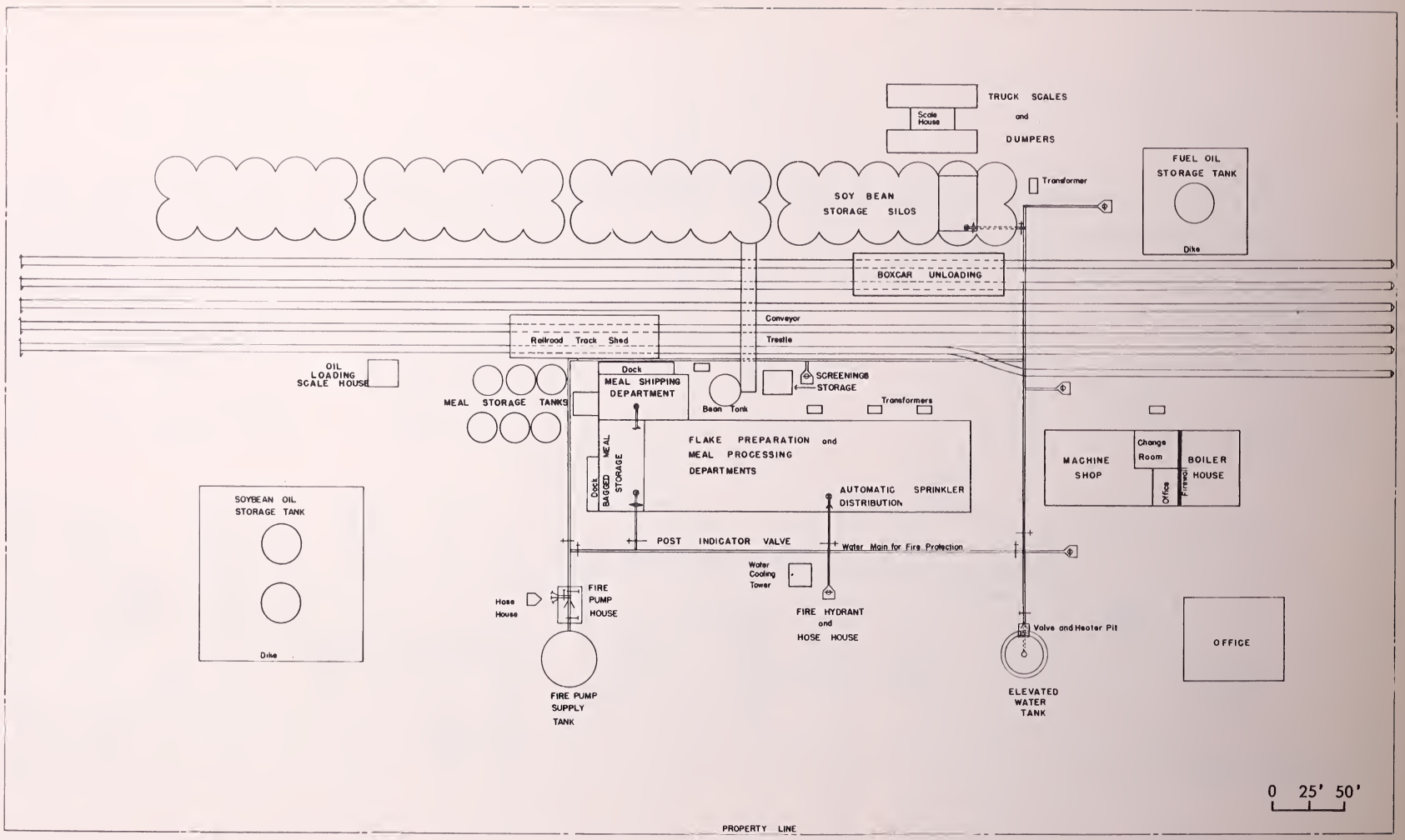


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FIGURE 6.—Property layout for a 24-press (600 tons per day) screw-press soybean oil mill, including fire-protection features. (Property layouts for 6-, 8-, 12-, 16-, 20-, and 32-press mills are similar.)

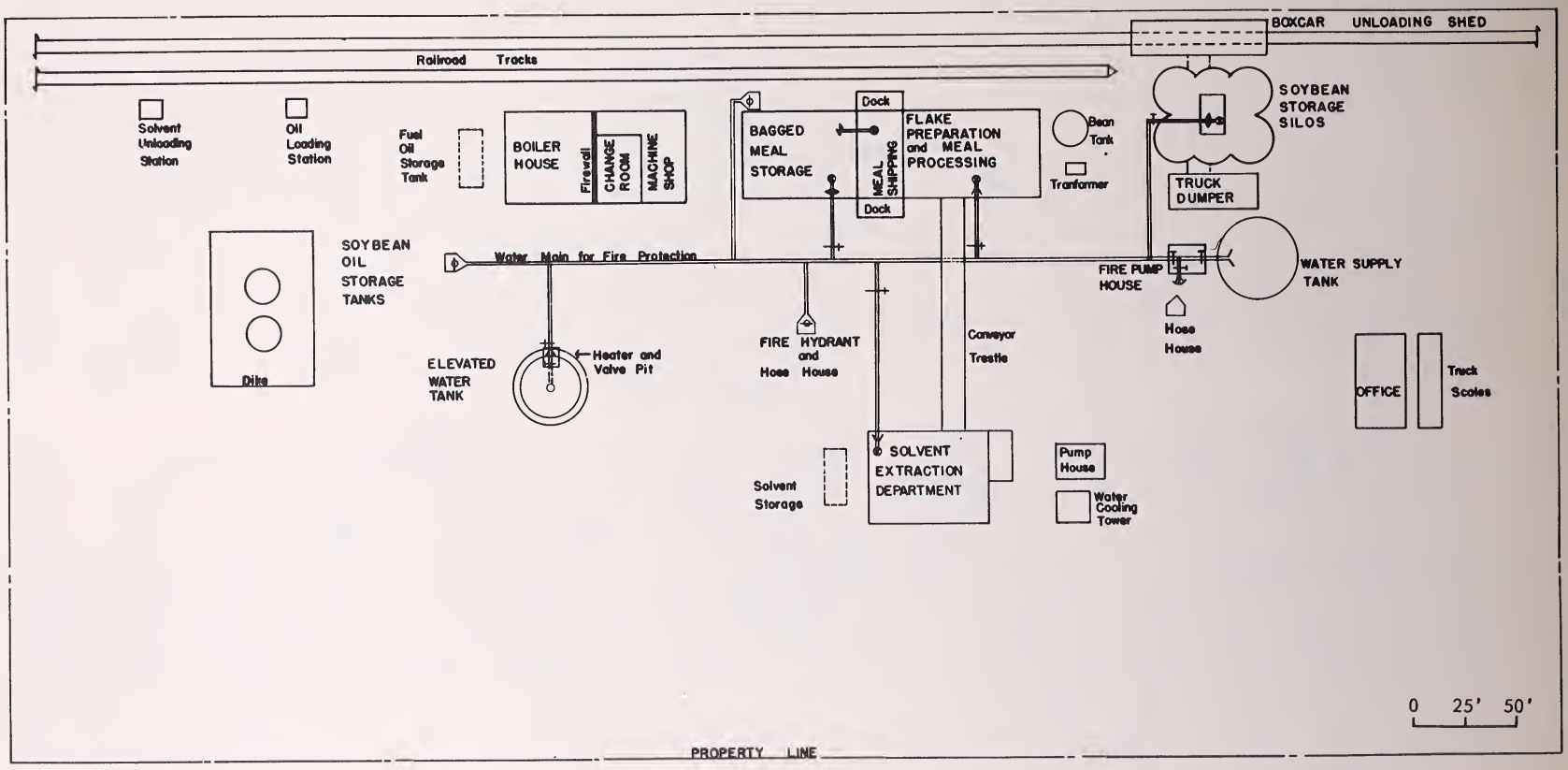

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FIGURE 7.—Property layout for a 100-ton-per-day solvent soybean oil mill. The layout shows also the fire-protection features. (Property layouts for 25- and 50-ton-per-day mills are similar.)

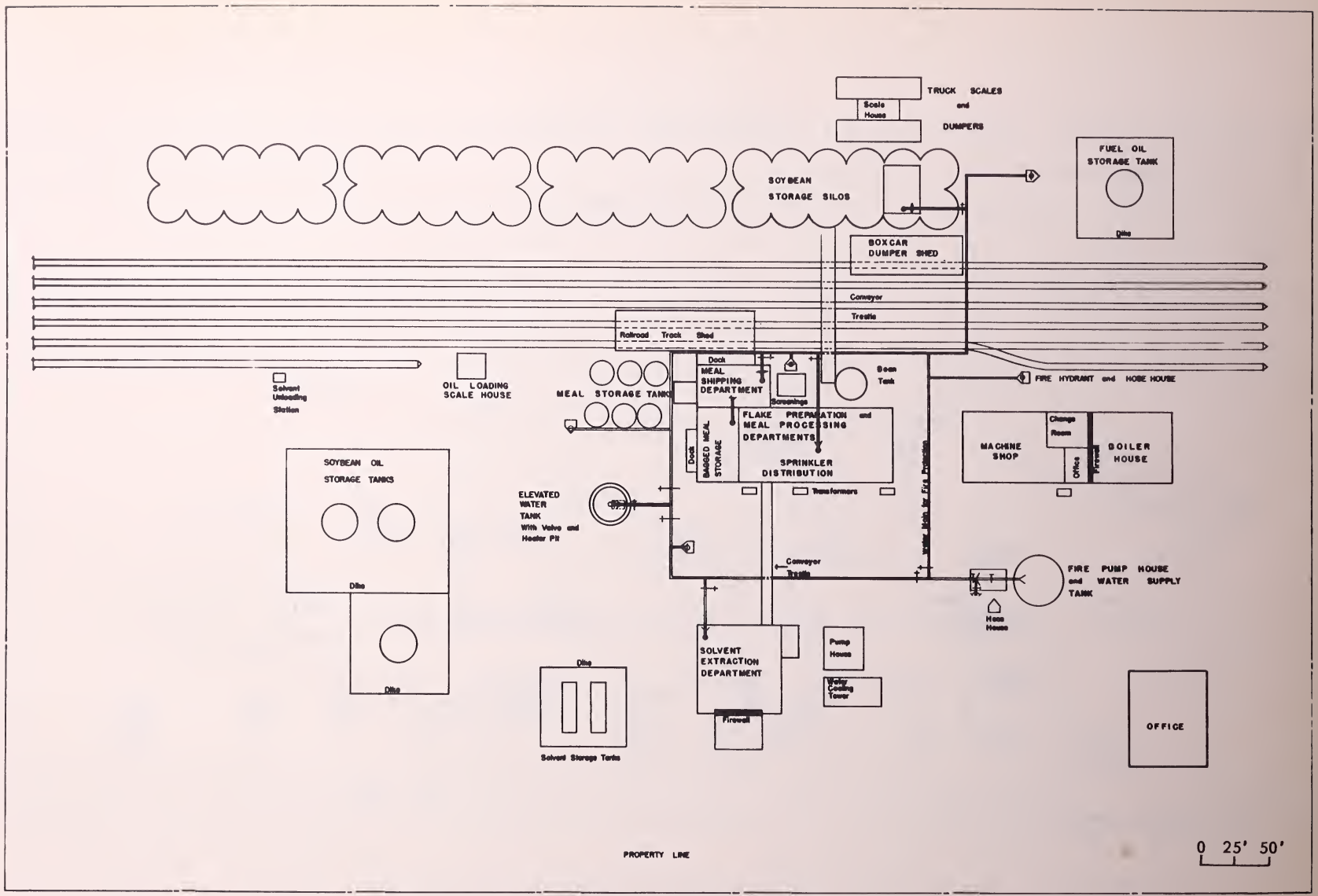

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FIGURE 8.—Property layout for a 600-ton-per-day solvent soybean oil mill. The layout shows also the fire-protection features. (Property layouts for 150-, 200-, 300-, 400-, 500-, 800-, and 1,000-ton-per-day mills are similar.)

CLASSIFICATION OF MATERIALS AND EQUIPMENT FOR TABULATION

For tabulating purposes, materials and equipment were grouped into two classes. Class 1 included all items which were estimated on the basis of unit costs, such as cubic yards of concrete, pounds of structural steel, lighting outlets, etc. This class of materials and equipment had installation labor estimated on the basis of an average cost per unit. Most class 1 items were assumed to be installed by contractors, and contractor's overhead and profits were included in installation costs. Class 2 includes most equipment items which were received in fabricated form, and the 1.27 multiplier calculated above was applied to this class. Buildings and tanks fell in class 1.

Class 2 items were assumed to be installed by the owner.

The total cost of a mill facility as determined by this method was the sum of the following:

(1) Class 1 M & E (materials and equipment).
(2) Installation and other costs for Class 1 M & E.
(3) Class 2 M & E.
(4) Installation and other costs for Class 2 M & E.
(5) Freight.

The overhead costs described above would be only those which could be charged directly to the job. If the mill were constructed by the owner, as has been assumed, certain home-office overhead costs might be applied in addition. Similarly, if the mill were constructed by a plant construction company, home-office overhead, profit, and maybe other costs would need to be applied. In neither case was a basis known for estimating these additional costs, and for the purposes of this study they were ignored.

Prices used for materials and equipment were principally those in effect during 1952. Some 1951 and 1953 equipment prices were used, but as little change occurred in equipment prices between 1951 and 1953, all prices used are believed to be comparable.

COST UNITS AND COST GROUPS

As the quantities of equipment and materials were calculated, they were tabulated and arranged according to either "cost units" or "cost groups." "Cost units" were prepared whenever the structure of a department needed to be made up of repeating units for the purposes of the study, or could more easily be estimated by the use of repeating units. "Cost groups" were prepared where each size of mill required some difference in design which the cost units would not fit, or where the use of cost units would not add to the ease of preparing estimates.

Cost units included all of the items of materials and equipment needed to carry out a single purpose. Cost units usually made complete structures themselves or when they were combined with a few other similar units, a complete structure was made. They were made up to be used like building blocks to build up a complete structure from increments. Examples are storage tanks for oil, soybean storage silos, center bays of buildings, and fire hydrants and hose houses. The use of given cost units was not restricted to any one mill. A set of units might be used in many different mills—to price warehouses, for example.

Where differences in sizes of mills required differences in design or equipment and a cost unit would fit only one or two sizes of mills, the equipment and materials were arranged into cost groups, usually according to type of equipment instead of according to a single function performed. The purpose of cost groups was to supply breakdowns of the costs. This procedure also aided pricing in that all items of the same description could be combined into a total before pricing instead of each item being priced individually. Examples of cost groups, such as conveyors and elevators, are in all of the tables of costs of processing departments. For various reasons, cost groups sometime included entire departments as in the case of the solvent extraction departments.

GENERAL PRINCIPLES

Some departments of the mills were designed and the costs were estimated in more detail than others. The degree of detail depended largely upon the practicability of increasing the accuracy of the overall estimates. Entering into decisions of the detail to be used were the amount of information available from manufacturers of equipment or other sources, and the magnitude of the errors in the overall estimate which might be caused by errors in the estimate of the particular department.

In general, as much economy was incorporated into the designs of the mills as was considered practical. Some designs were used which increased investment costs but lowered operating costs. Wherever feasible, standardization of a particular design for several mills was employed. The central purpose of the engineering phase of the study was to prepare as accurately, but also as rapidly as possible, complete estimates of investment costs for 11 different sizes of solvent and 10 different sizes of screw-press mills. Because of the particular problems and purposes of this study, the plant designs are not necessarily models of best engineering practice. Under different circumstances other designs might be more desirable. However, different designs would probably not alter significantly the comparative costs and revenues of different mills.

GENERAL FEATURES OF SOYBEAN OIL MILLS

For the mill property layouts (figs. 5 to 8), designs were developed which were similar to those

of actual mills and at the same time fitted as many different sizes of mills as practical. A layout along one side of railroad tracks was developed for both screw-press and solvent mills of sizes 25 through 100 tons per day (figs. 5 and 7) and a layout on on two sides of a group of railroad tracks was developed for larger mills (figs. 6 and 8). The layouts for large mills allowed room for the large number of soybean storage silos required.

In the screw-press mills designed, all bean processing is done in one building; in the solvent mills, processing is done in two buildings. The addition of the solvent extraction building is the chief difference between the layouts for the two types of mills.

One of the main factors determining the layout for solvent mills was the desirability of placing the solvent extraction building away from all fire hazards. For this reason, the extraction building is 100 feet or more away from all other structures except those associated with the extraction operation.

ELEVATOR DEPARTMENT

REQUIREMENTS FOR RECEIVING AND STORING SOYBEANS

Between two-fifths and one-half of the total soybeans crushed annually are received at mills at bean harvesttime during the months of October and November (table 42). Much larger mill receiving and storing facilities are needed for this period than is actually needed for average day-to-day mill operations throughout the season. For reasons stated on page 9, mills crushing from 25 through 400 tons per day were provided with facilities to store enough beans to supply the mill for approximately 80 days of operation, whereas larger mills were provided with enough for approximately 100 days (table 43).

TABLE 42.—*Percentage of total soybeans received and crushed at oil mills, by months, average of 1950–51 through 1952–53 seasons* [1]

Month	Received		Processed [2]	
	Percentage of total	Cumulated percentage	Percentage of total	Cumulated percentage
	Percent	*Percent*	*Percent*	*Percent*
October	33	33	9	9
November	14	47	9	18
December	7	54	9	27
January	6	60	10	37
February	6	66	9	46
March	6	72	9	55
April	5	77	8	63
May	5	82	8	71
June	5	87	7	78
July	3	90	7	85
August	3	93	7	88
September	7	100	6	[2] 92

[1] Based on data from Bureau of Census publications, *Facts for Industry, Series M17–1*, 1950 through 1953.

[2] Soybeans processed expressed as percentages of soybean receipts.

Beans are received at the mill by both trucks and railroad cars. Very small mills are usually local mills, buying a large portion of their beans direct from the farmer and therefore receive most of their beans by truck. Large mills buy in greater quantity from elevators at longer distances and receive most of their beans by rail. This practice of purchasing and receiving beans was taken into account in assigning unloading facilities for the different sizes of mills.

FLOW OF MATERIALS

Soybeans may be stored at oil mills in several different types of bins and in cottonseed storage houses. Beans are often stored in steel tanks, particularly in the South. However, the concrete-silo type of storage (fig. 9) is spreading into the South, and over the soybean area as a whole this "grain elevator" type of storage is by far the most popular. Accordingly all calculations made for this study were based on this type of storage.

This type of storage structure is often comprised of a double row of silos with belt conveyors running the length of the row, both on top and beneath the silos, to fill and empty them. The conveyors are served by bucket elevators in a "workhouse" at one end of the row of silos.

Beans are sampled and graded before being unloaded. Trucks are weighed before and after unloading to determine the net weight of beans. Railroad cars may be similarly weighed on railroad track scales, or the beans may be unloaded and weighed in hopper scales at the top of the elevator workhouse. From both boxcar and truck, beans are unloaded into hoppers feeding conveyors which discharge into bucket elevators. The elevators may raise the beans to the hopper scales or may discharge them directly to the conveyor to the silos.

Although practices vary, beans as received are often binned by 2-percent moisture ranges. The

FIGURE 9.—Aerial view of a solvent-extraction soybean oil mill.

TABLE 43.—*Soybean storage capacity required and capacity provided for northern soybean oil mills, by size of mill* [1]

Size of mill	Capacity required (approx.)[2]	Capacity provided						
		By basic storage unit				By increment storage unit		Total
		Symbol	Gross	Utilized by dryers and cleaners	Net	Unit	Amount	
Tons per day	*Bushels*	*Code*	*Bushels*	*Bushels*	*Bushels*	*Number*	*Bushels*	*Bushels*
25	70, 000	A	70, 000		70, 000			70, 000
50	140, 000	B	140, 000		140, 000			140, 000
100	280, 000	C	226, 000		226, 000	1	108, 000	334, 000
150	420, 000	C	226, 000	108, 000	118, 000	3	324, 000	442, 000
200	560, 000	D	251, 000	108, 000	143, 000	4	432, 000	575, 000
300	840, 000	D	251, 000	108, 000	143, 000	6	648, 000	791, 000
400	1, 120, 000	D	251, 000	108, 000	143, 000	9	972, 000	1, 115, 000
500	1, 750, 000	D	251, 000	108, 000	143, 000	15	1, 620, 000	1, 763, 000
600	2, 100, 000	E	248, 000	168, 000	80, 000	19	2, 052, 000	2, 132, 000
800	2, 800, 000	E	248, 000	216, 000	32, 000	26	2, 808, 000	2, 840, 000
1,000	3, 500, 000	E	248, 000	216, 000	32, 000	32	3, 456, 000	3, 488, 000

[1] Storage units provided for southern mills differ slightly for mills 200 tons per day and larger as shown in table 46.

[2] Equivalent to 80 days' processing capacity for mills 400 tons per day and under; 100 days' processing capacity for mills 500 to 1,000 tons per day. 1 ton is considered to be equivalent to 35 bushels.

Data from Texas Engineering Experiment Station.

higher the moisture content, the more susceptible soybeans are to spoilage. Therefore, beans containing over about 14 percent of moisture are usually either processed immediately, dried and put back in the silos, or mixed with much drier beans and returned to storage. All beans in storage are periodically turned, or removed from one silo, elevated, and returned to a different silo. During this procedure the beans are aerated and mixed to decrease their tendency to spoil by evening out their moisture content.

Bean cleaners and dryers are often provided in the workhouse. If cleaning equipment is available, the beans may be cleaned before they are returned to storage at the end of the first turning. Removal of foreign material decreases the spoilage tendency and the beans are further aerated and mixed. Beans may be cleaned before drying and are usually cleaned just before being sent to processing, even if they have been cleaned previously. If no cleaners are in the workhouse, cleaning in the mill before processing may be the only cleaning operation. If beans are dried in the workhouse, they are returned to storage for a while before processing in order to allow the remaining moisture to redistribute itself evenly through the beans.

DESCRIPTION AND COST OF FACILITIES FOR RECEIVING, STORING, AND DRYING SOYBEANS

The cost units of facilities for receiving, storing, and drying soybeans (table 44), can be combined in such a way as to estimate total costs of facilities ranging in size from less than 100,000 bushels' storage capacity to several million bushels' capacity. They can also be used to estimate the costs of different sizes of unloading, weighing, elevating, conveying, drying, and cleaning facilities of different descriptions. Each cost unit is complete, including all the accessory materials and equipment necessary to enable the principal machinery to function as it should.

For reasons previously stated (p. 2), economic comparisons of mills developed for this study were made on the basis of cost-price relationships typifying the central soybean-producing States. However, in the design of the mills, account was taken of certain structural differences between northern and southern mills. Generally speaking, except for the bean-storage departments, southern mills would differ less than northern mills might differ among each other. Therefore the only differences in design between northern and southern mills which might need to be considered are in bean-storage facilities. The reinforced-concrete-silo type of storage structure is being built in the South, and a further trend toward this type seems logical.

The principal differences which might develop between elevator facilities in the North and in the South depend upon (1) differences in proportions of beans received by trucks and by rail, and (2) type of fuel generally used. Estimates were developed for elevator facilities for both northern and southern locations. In no other departments of the mills were any differentiations made according to northern and southern locations.

The listing of the units in tables 45 and 46 is in the most logical form for specifying the type and number for each size mill. For example, the

TABLE 44.—*Description and costs of building and equipment units for receiving, storing, and drying soybeans in soybean oil mills, 1952–53 season*

Building and equipment	Storage capacity	Cost		
		Delivered	Installation	Total
Cleaners:	*Bushels*	*Dollars*	*Dollars*	*Dollars*
900 BPH (bushels per hour)	48,000	8,800	4,500	13,300
1,800 BPH (bushels per hour)	48,000	10,400	4,900	15,300
2,400 BPH (bushels per hour)	48,000	10,800	5,000	15,800
Dryers:				
150 BPH, gas heated		16,700	4,900	21,600
150 BPH, oil heated		16,800	5,300	22,100
300 BPH, gas heated		19,900	5,500	25,400
300 BPH, oil heated		20,000	6,000	26,000
500 BPH, gas heated	60,000	22,700	8,200	30,900
500 BPH, oil heated	60,000	23,800	7,700	32,500
1,000 BPH, gas heated	60,000	28,200	9,700	37,900
1,000 BPH, oil heated	60,000	29,900	11,000	40,900
Truck scales				6,000
Railroad track scales		15,000	5,000	20,000
1 small truck dumper		13,400	7,900	21,300
1 large truck dumper		31,200	15,900	47,100
2 large truck dumpers		58,800	26,600	85,400
1 railroad boxcar unloader		13,700	6,000	19,700
2 railroad boxcar unloaders		22,500	10,500	33,000
3 railroad boxcar unloaders		33,400	14,900	48,300
Railroad boxcar dumper				208,000
Bucket elevators:				
4,000 BPH, 120-foot centers		6,460	2,750	9,210
4,000 BPH, 164-foot centers		7,510	3,200	10,710
8,000 BPH, 164-foot centers		10,740	4,460	15,200
15,000 BPH, 164-foot centers		17,420	7,170	24,590
15,000 BPH, 212-foot centers		22,160	9,060	31,220
25,000 BPH, 212-foot centers		31,270	12,760	44,030
Terminals for distributing belt conveyors:				
24-inch belt width		2,420	1,850	4,270
30-inch belt width		6,090	2,430	8,520
36-inch belt width		7,300	2,850	10,150
42-inch belt width		8,190	3,200	11,390
Terminals for reclaiming belt conveyors:				
24-inch belt width		1,900	750	2,650
30-inch belt width		3,060	1,070	4,130
36-inch belt width		3,740	1,260	5,000
Basic storage units:				
A	70,000	30,700	26,800	57,500
B	140,000	57,000	52,100	109,100
C	226,000	88,900	83,300	172,200
D	251,000	132,000	123,000	255,000
E	248,000	237,000	227,000	464,000
Railroad switch engine—small				8,000
Railroad switch engine—large				20,000
Storage increment	108,000	28,000	28,000	56,000
Belt conveyor increments:				
24-inch belt width		670	260	930
30-inch belt width		780	300	1,080
36-inch belt width		970	360	1,330
42-inch belt width		1,180	420	1,600

Data from Texas Engineering Experiment Station.

selection of elevators depends upon unloaders, and therefore elevators are listed below unloaders; similarly, conveyors depend upon elevators and are listed below elevators.

Basic Storage Units

Five so-called basic storage units were designed to provide some storage, and to house elevators, hopper scales, cleaners, and dryers, as needed. For identification, the storage units were given letter designations "A" through "E". Storage units C, D, and E comprise a workhouse. Storage units A and B stand alone and include all of the storage required for small mills.

The plan for all 5 of the basic storage units is 4 round storage silos arranged in a square around a central well to contain the bucket elevators. The central well varies in area and height with the basic storage units in order to accommodate

larger and taller bucket elevators. The silos for storage units C, D, and E are 26 feet inside diameter and about 117 feet high. The silos for units A and B are smaller.

In units A, B, and C, the elevator well stops at the top of the silos and an elevator headhouse, of steel frame and corrugated siding construction, rises over the elevator well to house the tops of the elevators. In unit D, a concrete headhouse over the well rises above the tops of the storage silos to a total height of about 200 feet above the ground. Because hopper scales for weighing soybeans unloaded from railroad boxcars are necessary for installations comprised of 2 or 3 unloaders, storage unit D includes one hopper scale with receiving garner or bin over it, situated in the headhouse. Storage unit E includes two hopper scales to serve the boxcar dumper. They are located in extensions, to about 200 feet above the ground, of 2 of the 4 silos in the basic unit.

Some storage space for beans is available in the elevator wells if bins are built into the waste space in these wells. Estimates of this storage capacity are included in the storage capacities listed in table 5 for the different storage units.

Costs of basic storage units include costs for belt manlifts, lighting, allowance for dust collection, stairways to the top in most cases, and basements around the elevator boots. The basements connect with tunnels for the belt conveyors from the truck and railroad unloaders.

Storage Increment

The storage increment was designed to be added to the basic storage units C, D, and E only, to provide additional storage space. It is comprised of 2 flat-bottom silos side by side and tangent to each other with a conveyor underneath the 2 silos and a conveyor gallery across the top. The silos are 26 feet inside diameter and 117 feet high inside. With the interstice which is formed by every 4 silos tangent to each other, the storage increment has a capacity of about 108,000 bushels.

Cleaners and Dryers

The plan for the elevator department provided for the housing of bean cleaners and dryers in the four silos in basic storage units C, D, and E—one cleaner or dryer to a silo. By providing hopper bottoms in the silos, bins are formed over and under the cleaners and dryers, to feed or receive from these facilities. All the cleaners and the 500- and 1,000-BPH (bushels per hour) dryers were designed for this plan. When dryers and cleaners are installed in the silos included in the basic storage units, these silos are not available for storage. Accordingly, the volumes of these silos were subtracted from the capacities of the basic storage units (table 43).

Mills of 25- through 100-ton-per-day sizes were not provided with cleaners in the elevator department, as they were designed to have cleaners in the processing department. These mills also were designed to use outdoor, self-housed dryers, and the 150- and 300-BPH dryers are of this type. They are fed from bins in the silos, but they have no bins underneath them to receive dried beans. Consequently, beans must be elevated to storage as fast as they are dried, a process requiring extra machinery. Larger dryers which are housed in the basic storage units do not require this extra machinery. The costs of the large dryers (tables 45 and 46) do not include any charges for their housing. For this reason, and because the small dryers require more machinery, the costs listed for small dryers are nearly as great as the costs of large dryers. All the dryer cost units include scalping cleaners to partially clean the beans before drying them.

The cleaners and dryers (tables 45 and 46) were selected to provide capacity equivalent to about three times the normal hourly processing rate for cleaners, and twice the processing rate for dryers. This was done in order that these units would not need to operate continuously to supply the demands of the mill, and more efficient utilization of labor could be made. Oil-heated dryers were provided for northern mills, whereas gas-heated dryers were provided for southern mills, because of the type of fuel generally used in those locations.

Dryers were provided for all mills, although in some small mills they might not be necessary.

Unloaders

For unloading soybeans, three types of unloaders were used—truck dumpers, railroad boxcar unloaders, and railroad boxcar dumpers.

Truck Dumpers. The truck dumper cost units are for three sizes—1 small, 1 large, and 2 large dumpers. The units include hydraulically lifted platforms. Besides the dumpers, the units include sheds over the dumpers, hoppers to receive beans and feed them to belt conveyors, belt conveyors to the elevator legs, allowances for dust collecting facilities, and all accessory materials and equipment. The large dumpers also include scale-bean houses, and scales under the dumper platform, but the small dumper does not.

Truck dumpers for northern mills were selected on the basis of judgment of experienced operators. Southern mills, particularly of sizes 300 TPD and less, would probably receive most of their beans by truck. Therefore, truck dumpers for southern mills were selected to unload beans for 100 days' operation of the mills at normal rate, in 26 working days of 14 hours each. (This would take care of the so-called bean rush.) Average hourly unloading rates were assumed to be 2,000 BPH (bushels per hour) for small dumpers and 3,000 BPH for large dumpers. These figures resulted in one small dumper being required per 728,000 bushels to be unloaded in 26 days and one large dumper per 1,090,000 bushels to be un-

TABLE 45.—*Investment requirements for buildings and equipment for receiving, storing, and drying soybeans in northern soybean oil mills, by size of mill, 1952–53 season*

Building and equipment unit	Unit cost [1]	Size of mill (tons per day)																					
		25		50		100		150		200		300		400		500		600		800		1,000	
		Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost
	Dollars	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*
Cleaners:																							
900 BPH (bushels per hour)	13,300							1	13,300	1	13,300												
1,800 BPH (bushels per hour)	15,300											1	15,300	1	15,300					2	30,600		
2,400 BPH (bushels per hour)	15,800															1	15,800	1	15,800			2	31,600
Dryers:																							
150 BPH, oil heated	22,100	1	22,100	1	22,100																		
300 BPH, oil heated	26,000					1	26,000																
500 BPH, oil heated	32,500							1	32,500	1	32,500												
1,000 BPH, oil heated	40,900											1	40,900	1	40,900	1	40,900	2	81,800	2	81,800	2	81,800
Truck scales	6,000	1	6,000	1	6,000	1	6,000																
Railroad track scales	20,000	1	20,000	1	20,000	1	20,000	1	20,000														
1 small truck dumper	21,300	1	21,300	1	21,300	1	21,300																
1 large truck dumper	47,100							1	47,100	1	47,100	1	47,100	1	47,100	1	47,100						
2 large truck dumpers	85,400																	1	85,400	1	85,400	1	85,400
1 railroad boxcar unloader	19,700	1	19,700	1	19,700	1	19,700	1	19,700														
2 railroad boxcar unloaders	33,000									1	33,000	1	33,000	1	33,000								
3 railroad boxcar unloaders	48,300															1	48,300						
Railroad boxcar dumper	208,000																	1	208,000	1	208,000	1	208,000
Bucket elevators:																							
4,000 BPH, 120-foot centers	9,210	1	9,210																				
4,000 BPH, 164-foot centers	10,710			2	21,420	2	21,420																
8,000 BPH, 164-foot centers	15,200							2	30,400	1	15,200	2	30,400	2	30,400	2	30,400						
15,000 BPH, 164-foot centers	24,590																	2	49,180	2	49,180	2	49,180
15,000 BPH, 212-foot centers	31,220									1	31,220	1	31,220	1	31,220	1	31,220						
25,000 BPH, 212-foot centers	44,030																	1	44,030	1	44,030	1	44,030
Terminals for distributing belt conveyors:																							
30-inch belt width	8,520							1	8,520			1	8,520	1	8,520	1	8,520						
36-inch belt width	10,150									1	10,150	1	10,150	1	10,150	1	10,150	1	10,150	1	10,150	1	10,150
42-inch belt width	11,390																	1	11,390	1	11,390	1	11,390
Terminals for reclaiming belt conveyors:																							
24-inch belt width	2,650					2	5,300																
30-inch belt width	4,130							1	4,130	1	4,130	1	4,130	1	4,130	1	4,130						
36-inch belt width	5,000																	1	5,000	1	5,000	1	5,000
Basic storage units:																							
A	57,500	1	57,500																				
B	109,100			1	109,100																		
C	172,200					1	172,200	1	172,200														
D	255,000									1	255,000	1	255,000	1	255,000	1	255,000						
E	464,000																	1	464,000	1	464,000	1	464,000

Railroad switch engine—small	8,000									1	8,000	1	8,000	1	8,000	1	8,000							
Railroad switch engine—large	20,000																	1	20,000	1	20,000	1	20,000	
Storage increment	56,000					1	56,000	3	168,000	4	224,000	6	336,000	9	504,000	15	840,000	19	1,064,000	26	1,456,000	32	1,792,000	
Belt conveyor increments:																								
24 inches	930					2	1,860																	
30 inches	1,080							6	6,480	4	4,320	12	12,960	18	19,440	30	32,400							
36 inches	1,330									4	5,320	6	7,980	9	11,970	15	19,950	38	50,540	52	69,160	64	85,120	
42 inches	1,600																	19	30,400	26	41,600	32	51,200	
Total installed cost			155,810		219,620		349,780		522,330		683,240		840,660		1,019,130		1,391,870		2,139,690		2,576,310		2,938,870	

[1] Total installed cost from table 44.

Data from Texas Engineering Experiment Station.

TABLE 46.—*Investment requirements for buildings and equipment for receiving, storing, and drying soybeans in southern soybean mills, by size of mill, 1952–53 season*

Building and equipment unit	Unit cost [1]	Size of mill (tons per day)																					
		25		50		100		150		200		300		400		500		600		800		1,000	
		Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost
Cleaners:	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*
900 BPH (bushels per hour)	13,300							1	13,300	1	13,300												
1,800 BPH (bushels per hour)	15,300											1	15,300	1	15,300					2	30,600		
2,400 BPH (bushels per hour)	15,800															1	15,800	1	15,800			2	31,600
Dryers:																							
150 BPH, gas heated	21,600	1	21,600	1	21,600																		
300 BPH, gas heated	25,400					1	25,400																
500 BPH, gas heated	30,900							1	30,900	1	30,900												
1,000 BPH, gas heated	37,900											1	37,900	1	37,900	1	37,900	2	75,800	2	75,800	2	75,800
Truck scales	6,000	1	6,000	1	6,000																		
Railroad track scales	20,000	1	20,000	1	20,000	1	20,000	1	20,000	1	20,000	1	20,000	1	20,000								
1 small truck dumper	21,300	1	21,300	1	21,300																		
1 large truck dumper	47,100					1	47,100	1	47,100	1	47,100	1	47,100										
2 large truck dumpers	85,400													1	85,400	1	85,400	1	85,400	1	85,400	1	85,400
1 railroad boxcar unloader	19,700									1	19,700	1	19,700	1	19,700								
2 railroad boxcar unloaders	33,000															1	33,000	1	33,000				
3 railroad boxcar unloaders	48,300																			1	48,300	1	48,300
Bucket elevators:																							
4,000 BPH, 120-foot centers	9,210	1	9,210																				
4,000 BPH, 164-foot centers	10,710			1	10,710	1	10,710	1	10,710	1	10,710												
8,000 BPH, 164-foot centers	15,200					1	15,200	1	15,200	1	15,200	2	30,400	2	30,400	1	15,200						
15,000 BPH, 164-foot centers	24,590													1	24,590	1	24,590	2	49,180	2	49,180	2	49,180
15,000 BPH, 212-foot centers	31,220															1	31,220	1	31,220	1	31,220	1	31,220
Terminals for distributing belt conveyors:																							
30-inch belt width	8,520							1	8,520	1	8,520	1	8,520	1	8,520								
36-inch belt width	10,150													1	10,150	2	20,300	2	20,300	2	20,300	2	20,300
Terminals for reclaiming belt conveyors:																							
24-inch belt width	2,650					2	5,300	1	2,650	1	2,650												
30-inch belt width	4,130											1	4,130	1	4,130	1	4,130						
36-inch belt width	5,000																	1	5,000	1	5,000	1	5,000
Basic storage units:																							
A	57,500	1	57,500																				
B	109,100			1	109,100																		
C	172,200					1	172,200	1	172,200	1	172,200	1	172,200	1	172,200								
D	255,000															1	255,000	1	255,000	1	255,000	1	255,000
Railroad switch engine—small	8,000															1	8,000	1	8,000	1	8,000	1	8,000
Storage increment	56,000					1	56,000	3	168,000	4	224,000	7	392,000	9	504,000	15	840,000	19	1,064,000	26	1,456,000	32	1,792,000
Belt conveyor increments:																							
24-inch belt width	930					2	1,860	3	2,790	4	3,720												
30-inch belt width	1,080							3	3,240	4	4,320	14	15,120	18	19,440	15	16,200						
36-inch belt width	1,330													9	11,970	30	39,900	57	75,810	78	103,740	96	127,680
Total installed cost			135,610		188,710		353,770		494,610		572,320		762,370		963,700		1,426,640		1,718,510		2,168,540		2,529,480

[1] Total installed cost from table 44.

Data from Texas Engineering Experiment Station.

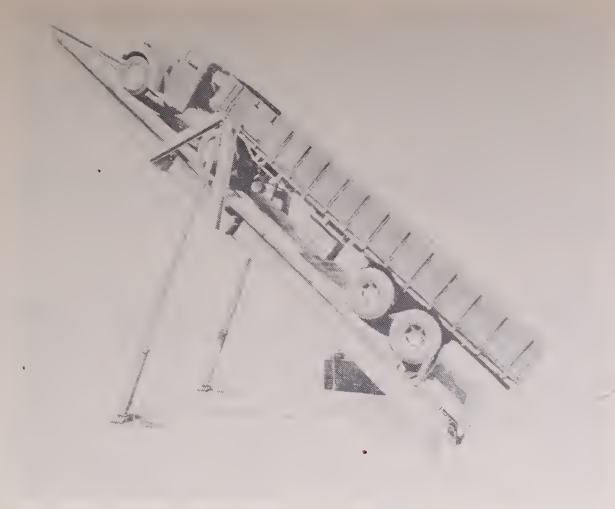

FIGURE 10.—Truck dumper.

loaded in the same period. Small dumpers were selected for only the three smallest mills. No more than two large dumpers were specified for the largest mills because railroad receipts become a large percentage of the total in large mills, even in the South.

RAILROAD BOXCAR UNLOADERS. Costs were estimated for 1-, 2-, and 3-railroad boxcar unloaders of the manually operated power shovel type. The costs include shovels, receiving pits, belt conveyors to bucket elevator legs, housing over the tracks and receiving pits, and allowances for dust collection.

For southern mills, boxcar unloaders were provided on the basis of judgment. As northern mills, especially in the larger sizes, receive most of their beans by rail, boxcar unloaders were selected to unload beans for 100 days of operation in 26 working days of 14 hours each. The average hourly unloading rate of each unloader was estimated to be 1,700 bushels per hour. These figures result in one unloader required per 619,000 bushels to be unloaded in 26 days.

RAILROAD BOXCAR DUMPERS. Railroad boxcar dumpers are of the type which tilt the cars both sidewise and endwise so that the contents will spill out of the door into a receiving hopper. Costs include dumper, housing, dust collection, belt conveyor to bucket elevator, and all accessories.

In selecting boxcar dumpers, a rule of thumb followed was: "A boxcar dumper is not justified until the rate of receipts reaches around five cars per hour." By using the average rate of soybean receipts as reported by the Bureau of Census (table 42), and assuming that most of the beans were received by rail in large northern mills, we estimated that a boxcar dumper was justified for northern mills of 600 tons per day size and larger (table 45). By the same rule of thumb, no boxcar dumpers were selected for southern mills.

FIGURE 11.—Grain being unloaded by a railroad boxcar unloader.

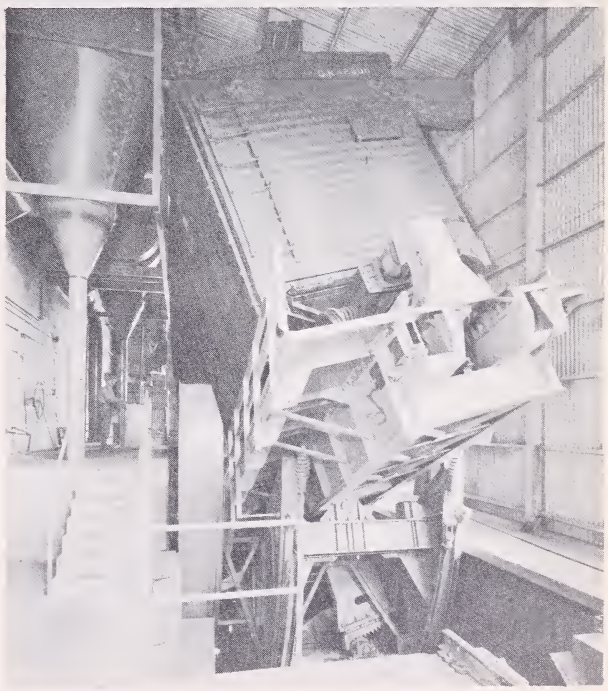

FIGURE 12.—Railroad boxcar being unloaded by a boxcar dumper.

Scales

The small truck dumper unit (table 44) does not include scales. For use with this unit, the truck scale unit in table 44 was provided. Large truck dumpers include scales as already described.

For mills without hopper scales in the workhouse, railroad track scales were supplied in the costs of the elevator department. In most cases these scales would also be used to weigh meal and oil shipped. Their costs are listed in table 44 and they are discussed further under the section on meal shipping (p. 77).

Bucket Elevators

Six different sizes of bucket elevators were used in transferring the unloaded soybeans to the storage silos. They were restricted in their use as follows:

Size of bucket elevator	*To be used only with—*
4,000 BPH (bushels per hour), 120-foot centers.	Basic storage Unit A.
4,000 BPH (bushels per hour), 164-foot centers.	Basic storage Unit A and 1 railroad boxcar unloader or 1 small truck dumper.
8,000 BPH (bushels per hour), 164-foot centers.	1 large truck dumper.
15,000 BPH (bushels per hour), 164-foot centers.	2 large truck dumpers.
15,000 BPH (bushels per hour), 212-foot centers.	2 or 3 railroad boxcar unloaders.
25,000 BPH (bushels per hour), 212-foot centers.	Railroad boxcar dumper.

FIGURE 13.—Belt conveyor in grain storage elevator. In the background is a movable tripper for unloading the belt into any silo in a row of silos.

In the 150 TPD (tons per day) northern mill and the 300 TPD southern mill (tables 45 and 46), 8,000 BPH elevators were selected because, with these larger elevators, one distributing conveyor was deemed sufficient to handle receipts by both truck and rail.

The bucket elevator costs include the elevator, drive, electrical accessories, and allowances for dust collection.

Belt Conveyors

Costs of belt conveyors for conveying beans from the elevators or scales to the storage silos or from silos back to the elevators were provided by the conveyor terminal and increment cost units. The four different sizes of distributing conveyor terminals in 24-, 30-, 36-, and 42-inch belt widths, were selected to be used with the 4,000, 8,000, 15,000, and 25,000 BPH bucket elevators, respectively. The distributing conveyor terminals include trippers for discharging beans from the belt.

Terminals for reclaiming belt conveyors were selected to match the elevator to be used for turning beans or elevating beans to cleaners or dryers.

The number of belt-conveyor increments required for different mills was equivalent to the product of the number of conveyor terminals and the number of storage increments.

Railroad Switch Engines

Small- and large-size railroad switch engines were provided. Small switch engines were selected on the basis of one for mills with two or more railroad boxcar unloaders. Large switch engines were selected for mills having boxcar dumpers.

PROCESSING DEPARTMENTS

In the mill processing departments, soybeans are changed into two products—soybean oil and soybean meal. The departments are described in terms of building and equipment for (1) flake preparation and meal processing in solvent mills; (2) oil extraction in solvent mills; and (3) soybean preparation, oil extraction, and meal processing in screw-press mills.

FLAKE PREPARATION AND MEAL PROCESSING DEPARTMENTS IN SOLVENT MILLS

The flake preparation and meal processing departments were located in the same building, along with the meal shipping and bagged meal storage departments (figs. 7, 8, 14–17). In the flake preparation department, soybeans are weighed (cleaned if not already done), cracked, conditioned, and flaked. The flakes are conveyed to the oil extraction department, and cooled meal is conveyed back to the meal processing department. Here meal is screened and ground, and ground screenings are added as the meal is conveyed to storage.

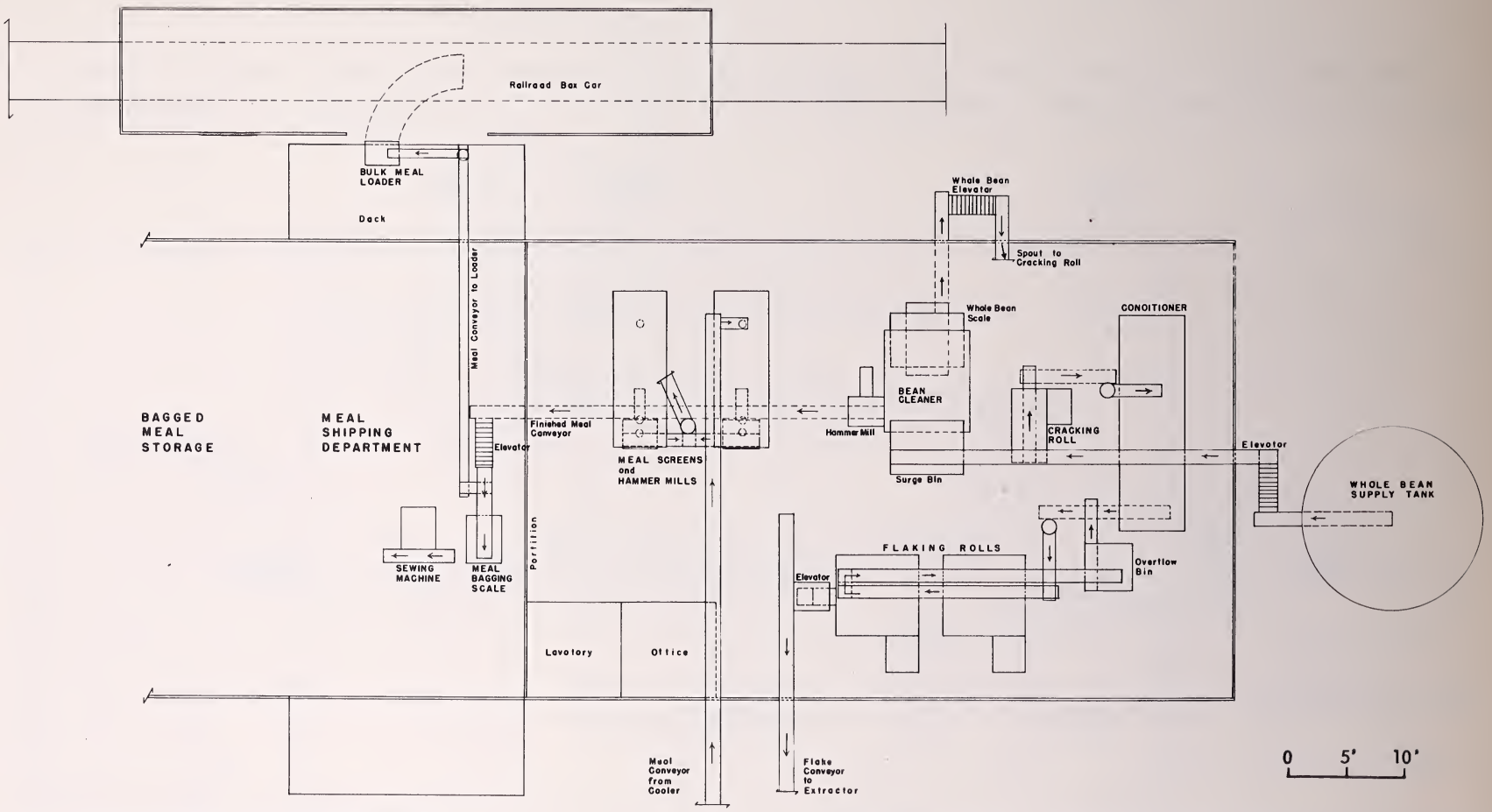

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FIGURE 14.—Soybean preparation, meal processing, and meal shipping departments for a 100-ton-per-day solvent soybean oil mill. (The 25- and 50-TPD mills are similar.)

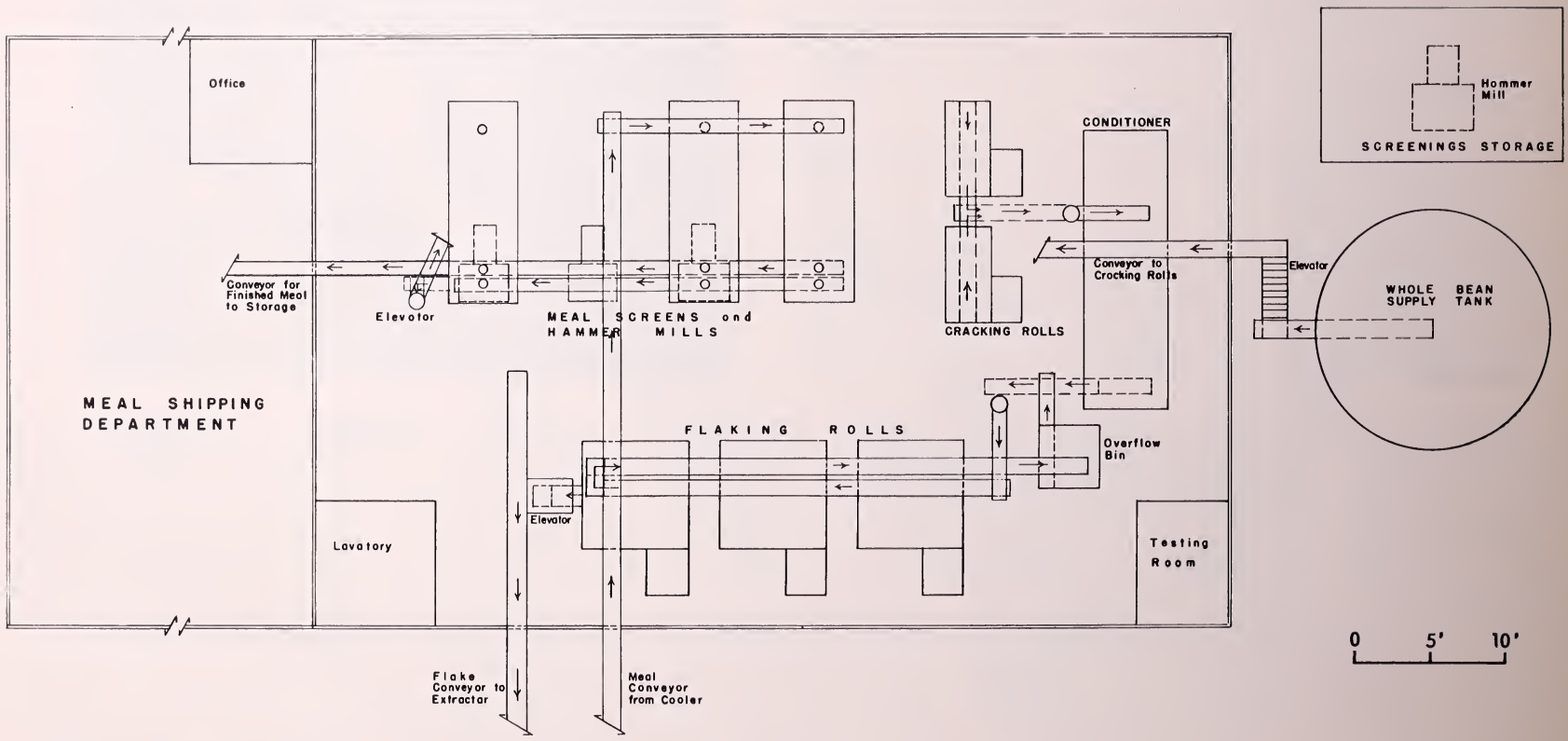

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FIGURE 15.—Soybean preparation and meal processing departments for a 200-ton-per-day solvent soybean oil mill. (The 150-TPD mill is similar.)

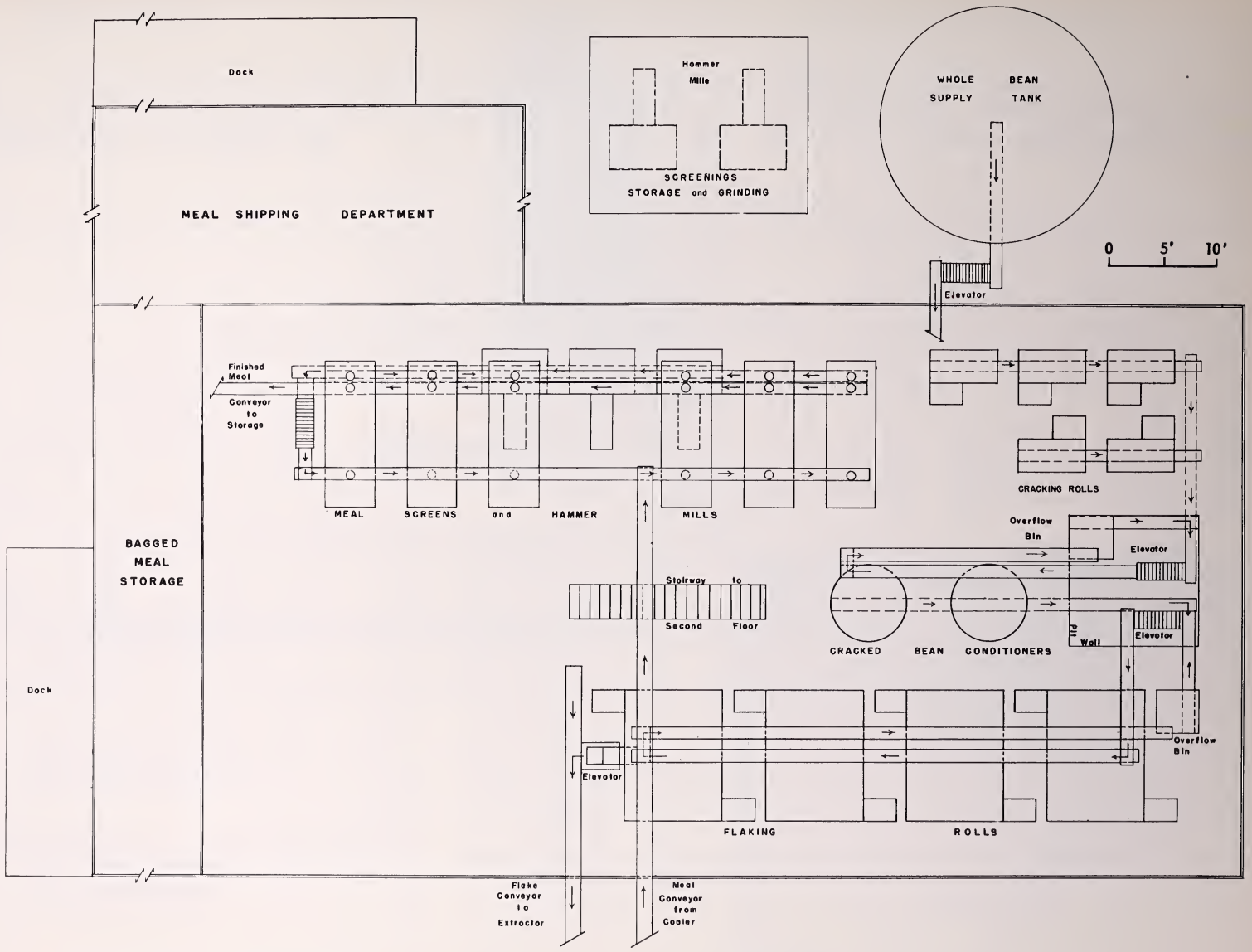

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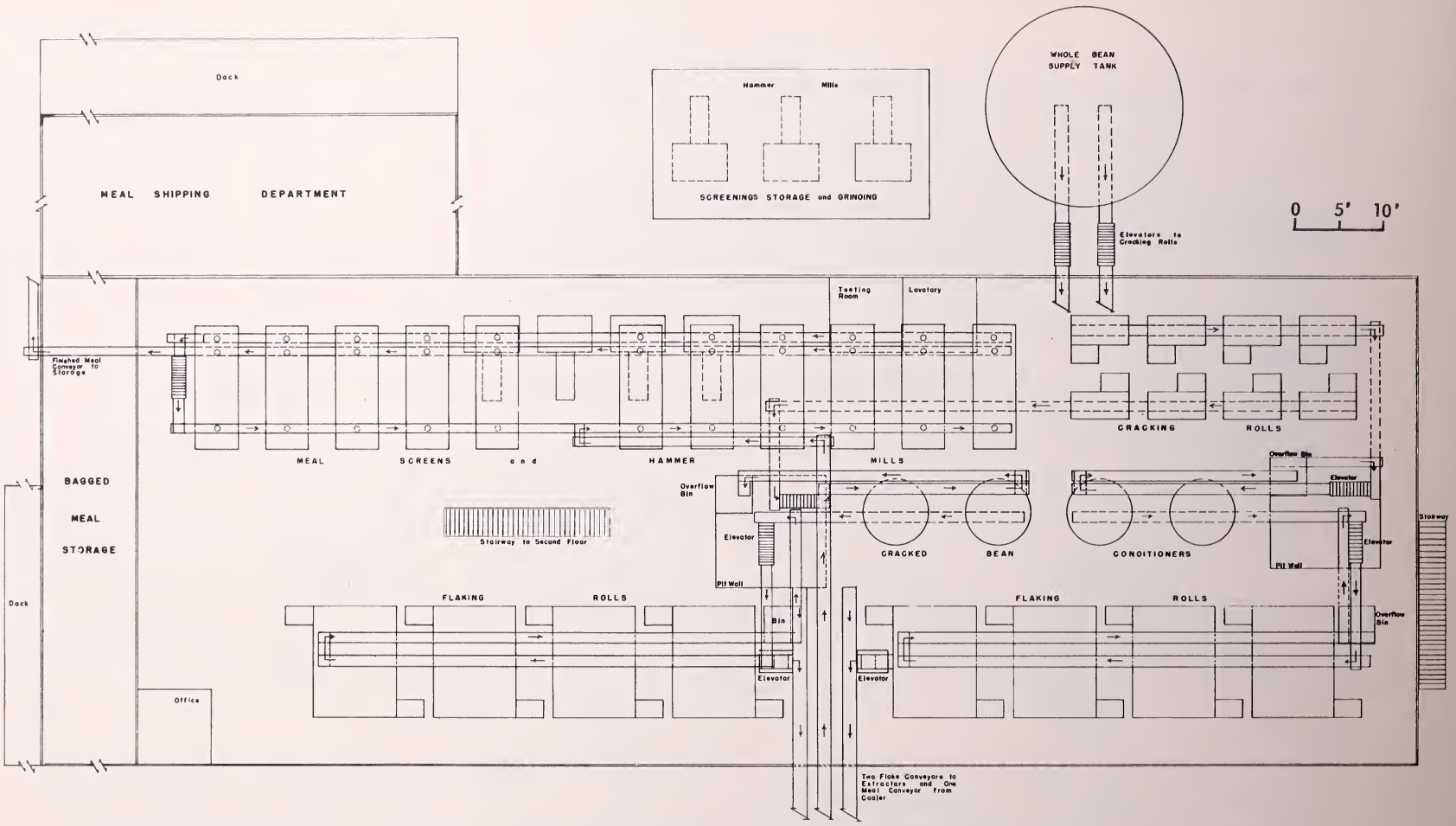
FIGURE 16.—Soybean preparation and meal processing departments for a 500-ton-per-day solvent soybean oil mill. (The 300- and 400-TPD mills are similar.)



U. S. DEPARTMENT OF AGRICULTURE NEG. 4092-56 (4) AGRICULTURAL MARKETING SERVICE

FIGURE 17.—Soybean preparation and meal processing departments for a 1,000-ton-per-day solvent soybean oil mill. (The 600- and 800-TPD mills are similar. Provision is made for two parallel flows of material through preparation but not through meal processing operation.)

For mills above 500 TPD, two parallel flows of material were provided through the preparation operations (fig. 17).

The flow of materials in different size mills is illustrated in figures 14–17.

Building for Flake Preparation and Meal Processing

The building, housing flake preparation and meal processing operations in solvent mills, is of steel-frame, galvanized-iron-siding construction and of trussless, rigid-frame design. It was designed with two main floor levels. The first floor is concrete with some recesses and pits as shown in figures 14 through 17. It is 4 feet above the ground. The second-floor level was constructed of steel grating supported on beams and columns. The entire building is 20 feet from top of foundation to eaves in all sizes of mills.

The building for the 150-TPD mill is smaller than that for the 100-TPD mill because, according to the design, bean cleaning is done in the preparation department in all mills through 100 TPD. But beginning with the 150-TPD size of mill, cleaning is done in the elevator department.

Costs of these buildings are given in table 47 for all sizes of mills. Each cost is for a section, being planned and priced as the section of one large building.

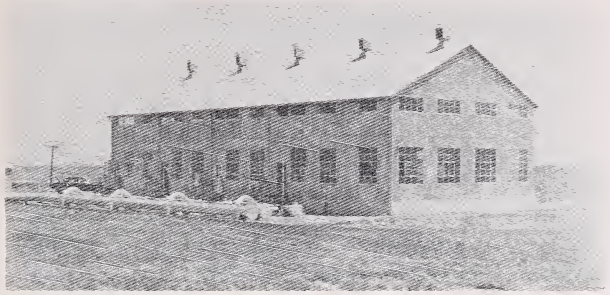


FIGURE 18.—A steel frame building of the type selected for nearly all buildings in this study.

FIGURE 19.—Interior of building of type shown in figure 18.

Equipment for Flake Preparation and Meal Processing

Machinery for flake preparation and meal processing was arranged on two main-floor levels. Some conveyors, and elevators were recessed into the first floor in pits (figs. 14–17). Meal screens were the principal items of equipment entirely on the second floor.

TABLE 47.—*Description and investment requirements of building sections for flake preparation and meal processing in solvent soybean oil mills, by size of mill, 1952–53 season*

Size of mill	Description		Cost		
	Dimension	Area	Delivered	Installation	Total
Tons per day	*Feet*	*Square feet*	*Dollars*	*Dollars*	*Dollars*
25	60 by 38	2, 280	21, 020	9, 960	30, 980
50	60 by 38	2, 280	21, 020	9, 960	30, 980
100	60 by 38	2, 280	21, 020	9, 960	30, 980
150 [1]	50 by 38	1, 900	18, 220	8, 700	26, 920
200	60 by 38	2, 280	21, 020	9, 960	30, 980
300	70 by 52	3, 640	30, 310	14, 450	44, 760
400	80 by 52	4, 160	33, 860	16, 060	49, 920
500	100 by 52	5, 200	40, 950	19, 270	60, 220
600	110 by 52	5, 720	45, 110	21, 500	66, 610
800	120 by 52	6, 240	48, 650	23, 100	71, 750
1,000	140 by 52	7, 280	55, 740	26, 320	82, 060

[1] The preparation building for the 150-ton-per-day mill is smaller than that for the 100-ton-per-day mill because according to the design soybean cleaning is done in the preparation department in all mills through 100 tons per day, but beginning with the 150-ton-per-day size, cleaning is done in the soybean storage silos.

Data from Texas Engineering Experiment Station.

TABLE 48.—*Investment requirements for equipment for flake preparation and meal processing in solvent soybean oil mills, by size of mill, 1952–53 season*

Equipment group	Size of mill (tons per day)																	
	25			50			100			150			200			300		
	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Whole soybean conveyor from storage										11,840	5,370	17,210	11,840	5,370	17,210	11,840	5,370	17,210
Whole soybean supply tank	3,390	1,450	4,840	3,390	1,450	4,840	4,260	1,830	6,090	4,410	2,250	6,660	4,410	2,250	6,660	4,410	2,250	6,660
Soybean cleaner and scales	5,790	2,340	8,130	6,160	2,500	8,660	6,580	2,530	9,110									
Whole soybean scales										1,230	340	1,570	1,230	340	1,570	1,230	340	1,570
Cracking rolls	3,920	1,120	5,040	5,640	1,650	7,290	8,540	2,580	11,120	17,080	5,160	22,240	17,080	5,160	22,240	25,630	7,740	33,370
Conditioners	5,620	1,780	7,400	5,620	1,780	7,400	10,670	3,170	13,840	10,670	3,170	13,840	15,560	4,620	20,180	16,120	4,470	20,590
Flaking rolls	10,780	3,200	13,980	10,780	3,200	13,980	20,990	6,080	27,070	31,460	8,960	40,420	48,380	13,320	61,700	64,340	18,070	82,410
Conveyors for preparation	5,130	1,550	6,680	5,130	1,550	6,680	6,100	1,900	8,000	5,460	1,620	7,080	5,740	1,750	7,490	11,450	4,240	15,690
Elevators for preparation	7,600	2,310	9,910	7,600	2,310	9,910	8,840	2,820	11,660	6,650	2,160	8,810	6,650	2,160	8,810	9,180	2,940	12,120
Meal screens and hammer mills	10,600	3,810	14,410	11,940	4,140	16,080	12,200	4,300	16,500	16,000	5,320	21,320	21,530	6,620	28,150	28,190	8,470	36,660
Conveyors for meal processing	1,970	690	2,660	1,970	690	2,660	2,330	820	3,150	4,120	1,370	5,490	4,930	1,740	6,670	6,650	2,470	9,120
Elevators for meal processing	1,530	520	2,050	1,530	520	2,050	1,820	600	2,420	2,050	670	2,720	2,050	670	2,720	2,830	830	3,660
Electric power distribution	360	110	470	740	230	970	1,720	430	2,150	1,890	420	2,310	2,000	580	2,580	3,600	940	4,540
Miscellaneous materials and equipment	2,080	600	2,680	2,080	600	2,680	2,080	600	2,680	3,720	1,480	5,200	3,720	1,480	5,200	3,720	1,480	5,200
Facilities for storage and grinding of soybean screenings										9,360	3,060	12,420	9,870	3,205	13,075	17,020	5,355	22,375
Total cost of equipment:																		
Indianapolis, Ind.[1]	58,770	19,480	78,250	62,580	20,620	83,200	86,130	27,660	113,790	125,940	41,350	167,290	154,999	49,265	204,255	206,210	64,965	271,175
Memphis, Tenn	59,240	19,480	78,720	63,060	20,620	83,680	86,780	27,660	114,440	126,540	41,350	167,890	155,810	49,265	205,075	207,300	64,965	272,265
Waterloo, Iowa	58,970	19,480	78,450	62,780	20,620	83,400	86,460	27,660	114,120	126,310	41,350	167,660	155,540	49,265	204,805	207,040	64,965	272,005

Equipment group	400			500			600			800			1,000		
	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Whole soybean conveyor from storage	19,280	7,470	26,750	19,280	7,470	26,750	19,280	7,470	26,750	19,280	7,470	26,750	19,280	7,470	26,750
Whole soybean supply tank	5,980	2,600	8,580	5,980	2,600	8,580	5,980	2,600	8,580	5,980	2,600	8,580	5,980	2,600	8,580
Soybean cleaner and scales															
Whole soybean scales	1,230	340	1,570	1,230	340	1,570	2,460	680	3,140	2,460	680	3,140	2,460	680	3,140
Cracking rolls	34,170	10,320	44,490	42,710	12,900	55,610	51,490	16,020	67,510	51,490	16,020	67,510	68,670	21,360	90,030
Conditioners	25,630	7,550	33,180	28,370	8,260	36,630	30,850	8,930	39,780	50,980	15,000	65,980	56,730	16,530	73,260
Flaking rolls	80,590	22,670	103,260	107,320	30,100	137,420	107,320	30,100	137,420	160,830	45,110	205,940	214,120	49,980	264,100
Conveyors for preparation	13,370	5,210	18,580	13,540	5,710	19,250	22,260	8,300	30,560	26,850	10,490	37,340	29,710	11,590	41,300
Elevators for preparation	10,050	3,200	13,250	10,340	3,300	13,640	18,380	5,900	24,280	20,040	6,230	26,270	20,700	6,570	27,270
Meal screens and hammer mills	33,460	10,000	43,460	38,460	11,280	49,740	46,580	13,670	60,250	57,010	16,660	73,670	65,790	18,440	84,230
Conveyors for meal processing	7,220	2,690	9,910	8,280	3,110	11,390	10,210	3,620	13,830	11,000	3,920	14,920	14,420	5,210	19,630
Elevators for meal processing	3,050	900	3,950	3,100	1,070	4,170	2,950	860	3,810	3,340	980	4,320	3,660	1,070	4,730
Electric power distribution	3,900	1,100	5,000	4,470	1,410	5,880	5,990	1,730	7,720	6,600	2,080	8,680	8,440	2,570	11,010
Miscellaneous materials and equipment	3,720	1,480	5,200	3,720	1,480	5,200	5,310	1,790	7,100	5,310	1,790	7,100	5,310	1,790	7,100
Facilities for storage and grinding of soybean screenings	17,310	5,425	22,735	20,165	6,205	26,370	21,830	6,580	28,410	25,190	7,495	32,685	31,480	9,445	40,925
Total cost of equipment:															
Indianapolis, Ind.[1]	258,960	80,955	339,915	306,965	95,235	402,200	350,890	108,250	459,140	446,360	136,525	582,885	546,750	155,305	702,055
Memphis, Tenn	260,380	80,955	341,335	308,690	95,235	403,925	352,840	108,250	461,090	449,025	136,525	585,550	550,000	155,305	705,305
Waterloo, Iowa	260,080	80,955	341,035	308,400	95,235	403,635	352,405	108,250	460,655	448,620	136,525	585,145	549,535	155,305	704,840

[1] Indianapolis, Ind., was used as the price basing point for individual items. Differences from the Indiana totals at the other price basing points were owing to differences in delivered cost of machinery.

Data from Texas Engineering Experiment Station.

Total costs of equipment for flake preparation and meal processing are given in table 48 for all sizes of mills, with additional description and number of machines required given in table 49. As the costs are grouped by category in table 48, separate costs of the machines listed in table 49 are not shown.

Characteristics of the equipment units listed in table 48 may be described in the order of the operations they perform.

Whole Bean Conveyor From Storage. The whole bean conveyor is included in mills of sizes 150 TPD and larger. It is fed beans by gravity from bins in the storage silos and conveys them to the whole bean supply tank. It is located on a trestle about 25 feet above the ground.

Whole Bean Supply Tank. The whole bean supply tank, situated outside the preparation building, is a storage tank which supplies beans to the preparation department. In 25-through 100-TPD mills, beans are spouted to it from the storage silos whereas in larger mills they are received by conveyor.

Whole Bean Cleaner. Bean cleaners are included in the preparation department only in mill sizes up through 100 TPD, as cleaning is done in the elevator department in larger mills. Included in the costs are hammer mills for grinding the screenings. Cleaners are shaker screens equipped with fans which separate foreign material from beans by differences in particle size and density.

Whole Bean Scale. Two sizes of bean scales (170 and 1,200 TPD) were provided for weighing the cleaned beans automatically to measure the rate and amount of beans processed.

Cracking Rolls. Cracking rolls break beans into small pieces which may be more easily heated and flaked than whole beans. Cracking rolls are comprised of 2 or 3 pairs of solid steel rolls arranged one pair above the other. The rolls turn toward each other at the top, and they are grooved with sawtoothed corrugations which cut the particles of beans as they pass down between the rolls in each pair.

Table 49.—*Number of principal machines required for flake preparation and meal processing in solvent soybean oil mills, by size of mill* [1]

Machine	Approximate maximum rate per day	Size of mill (tons processed per day at normal operating rate)										
		25	50	100	150	200	300	400	500	600	800	1,000
	Tons	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Soybean cleaner	41	1										
Do	82		1									
Do	125			1								
Whole soybean scale:												
2 bushel	170	1	1	1								
6 bushel	1, 200				1	1	1	1	1	2	2	2
Cracking roll:												
2 high, 10 by 24 inch	43	1										
2 high, 10 by 42 inch	100		1									
3 high, 10 by 42 inch	150			1	2	2	3	4	5	6	6	8
Conditioner:												
Horizontal	100	1	1	2	2	3						
Stack cooker, 4 high 85 inch	250							2			4	
Stack cooker, 5 high 85 inch	315								2			4
Stack cooker, 6 high 85 inch	375						1			2		
Flaking rolls:												
Single stand, 24 by 24 inch	60	1	1	2								
Single stand, 24 by 40 inch	100				2	3	4					
Double stand, 20 by 42 inch	175							3	4	4	6	8
Meal screen:												
1 deck, 40 by 60 inch	100	2	2									
1 deck, 40 by 84 inch	140			2								
1 deck, 40 by 120 inch	200				2	3	4	5	6	7	9	11
Hammer mills for meal and screenings		3	3	3	2	3	3	3	3	4	4	4

[1] Costs of these machines are included in costs given in table 48. Requirements are based on mills operating at maximum rates.

Data from Texas Engineering Experiment Station.

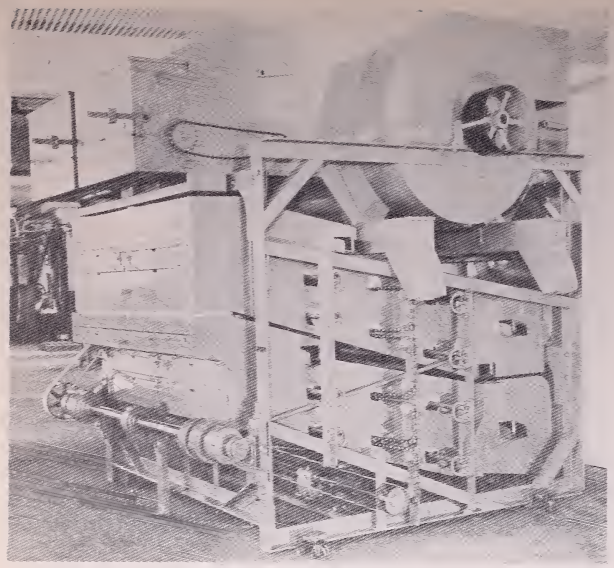


FIGURE 20.—One type of cleaner for whole soybeans.

FIGURE 21.—Three-pair-high cracking roll. (A second machine is shown in the background.)

CONDITIONERS. Conditioners heat cracked beans to the temperature desired for flaking. Also some drying of the cracked beans usually results during heating. Conditioners take different forms. Horizontal conditioners, provided for mills in this study, are comprised of horizontal steam-heated pipes arranged in a bundle which turns inside a stationary housing. Blades attached to the rotating bundle continually lift the beans to allow them to fall around the heated pipes in the bundle. Stack cooker conditioners consist of steam-jacketed kettles stacked one on top of the other with an opening in the bottom of each through which the material, being heated, can fall from kettle to kettle. In each kettle the cracked beans are agitated by a sweep fastened to a central shaft.

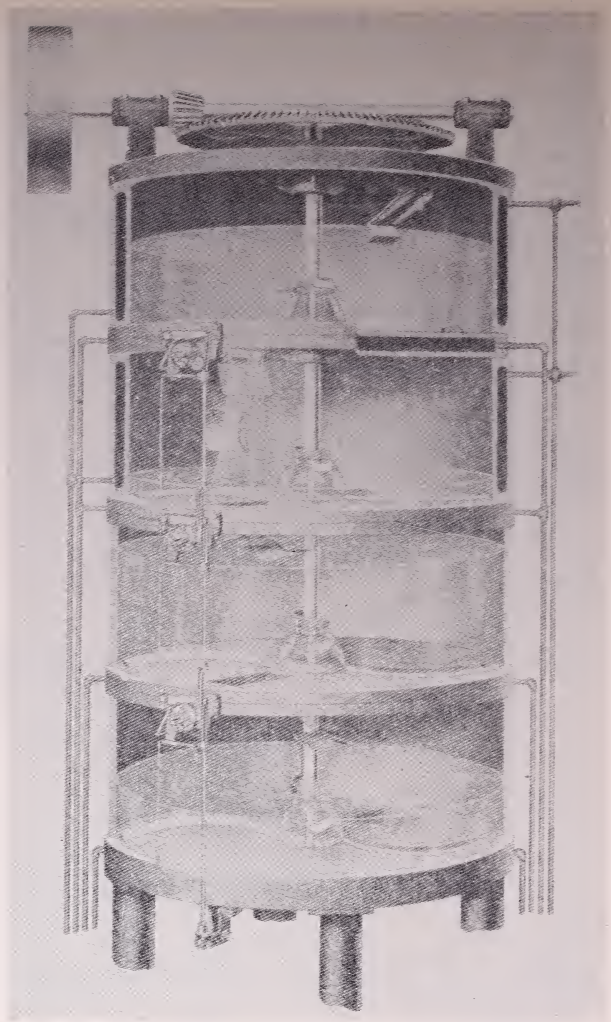


FIGURE 22.—Phantom view of stack conditioner.

FLAKING ROLLS. Flaking rolls roll the heated cracked beans into flakes about 0.008 inch thick. A single stand of rolls consists of 2 solid steel rolls arranged side by side in a horizontal plane. The rolls are about 2 feet in diameter and from 2 to 4 feet long. They turn together at the top and flatten the cracked beans as they pass downward between the rolls. A double stand of rolls is essentially 2 single stands mounted in the same frame. The flow of cracked beans to a double stand machine is split by feeders into 2 streams which then pass through the 2 sides of the machine.

MEAL SCREENS AND HAMMER MILLS. The purpose of meal-processing operations is to reduce the particle size of the meal to a certain narrow range

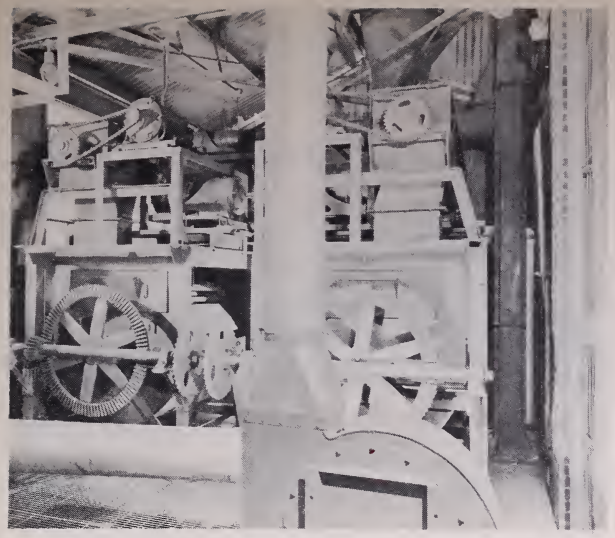


FIGURE 23.—Two horizontal cracked bean conditioners in a soybean mill.

of granular sizes. This is accomplished by screening the cooled meal to separate all meal above a certain size from finer particles which go directly to finished meal. The large particles are ground and rescreened, with the larger particles from the second screening going to a second stage of grinding from which ground material is returned to the second screening stage. Fine meal from the second screening stage goes to finished meal. The meal screens and hammer mills cost groups include screens and hammer mills for two stages of screening and grinding and include motors, starters, machinery supports, and other accessory equipment.

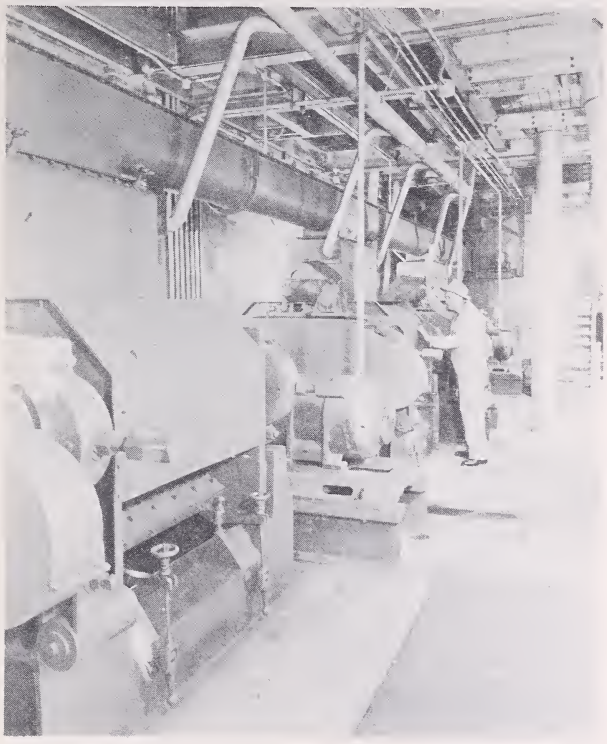


FIGURE 24.—Three single-stand flaking rolls installed in a soybean mill.

FACILITIES FOR STORAGE AND GRINDING OF SOYBEAN SCREENINGS. In mills of sizes 150 TPD and larger, the soybean screenings that come from the cleaners in the storage elevators are conveyed along the trestle for the whole bean conveyor to a steel bin situated near the cleaned bean supply tank and there they are stored until ground and returned to the meal. Underneath the bin and sheltered by it are hammer mills for grinding screenings as they are needed for addition to the meal. The costs of these facilities include costs of the storage bin, hammer mills, and conveyors to perform these operations. In mills of 100 TPD and smaller, as bean cleaning is done in the mill, no storage of screenings is necessary.

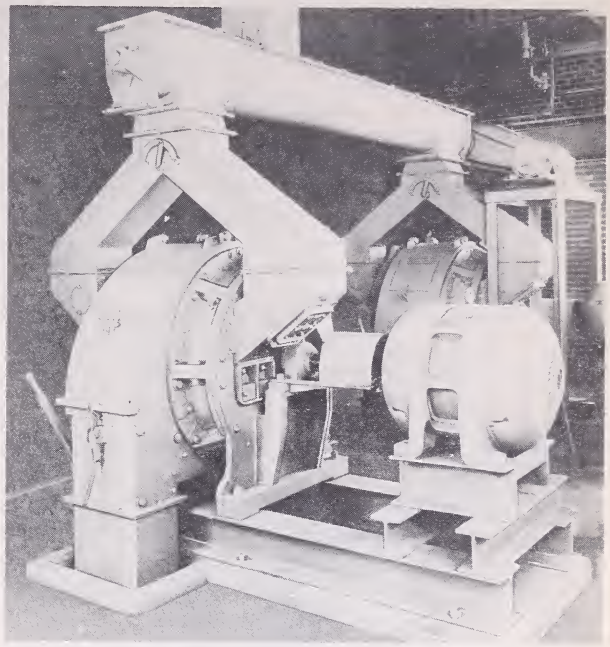


FIGURE 25.—Hammer mills for grinding meal in a soybean mill.

ELECTRIC POWER DISTRIBUTION. Insofar as possible, all costs for electric power distribution were distributed between substation costs and the various machinery cost units or cost groups. All of the cost groups which have been described have included motors, starters, electric control center circuit breakers, and wiring from control centers to motors. The electric power distribution category includes chiefly electrical feeder wiring from transformers to control center, circuit breaker to protect the feeder, and similar items which could not be divided equitably among the other cost groups.

OIL EXTRACTION DEPARTMENTS IN SOLVENT MILLS

The solvent extraction department in solvent mills was housed in a separate building from flake preparation and meal processing operations, as shown in figures 7 and 8. Prepared flakes are conveyed from the preparation department across an uncovered trestle to the extraction department where the oil is extracted and the meal is desolventized, toasted, and cooled. The cooled meal is conveyed back across the trestle to the meal processing equipment.

For all departments of the mills, usually equipment from several different manufacturers was available and often no particular procedure was followed in choosing the equipment to be priced and included in the cost estimates. For the solvent extraction department, relatively few manufacturers make this type of equipment, and more differences exist among equipment from different manufacturers than for other departments. Also the manufacturers commonly sell to each customer essentially all of the machinery going into this department, which is not always the case in other departments. Therefore, for the solvent extraction department, estimates were made for equipment from more than one different manufacturer. To avoid comparing equipment of different manufacturers, the costs shown in table 50 are averages of all the estimates made. They will approximate the costs of solvent extraction departments of any manufacture.

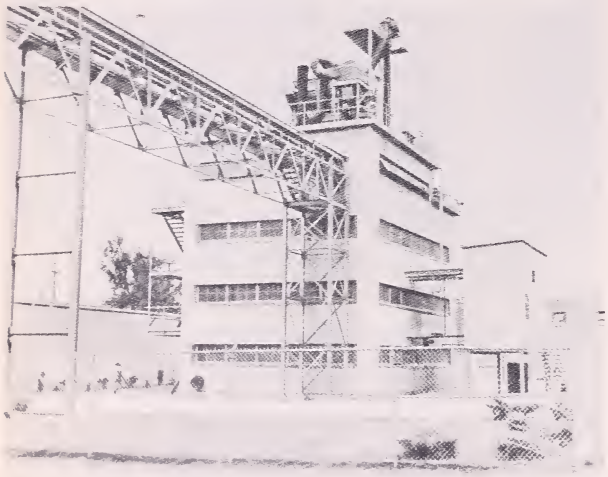


FIGURE 26.—Solvent-extraction building of type selected for this study.

Buildings for Solvent Extraction Department

The solvent extraction buildings are of steel-frame construction with asbestos-cement siding. The dimensions and design of the buildings vary with the manufacture of the equipment, as well as with the size of mill. Insofar as possible, necessary differences in building design were incorporated into estimates of departments with equipment of different manufacture. Therefore, more specific description of the solvent extraction buildings cannot be given.

FIGURE 27.—Construction view of an outdoor installation of one type of plant for solvent extraction of oil from flaked soybeans. The preparation and meal building is on the right. In the background are soybean storage silos.

Equipment in Solvent Extraction Departments

The solvent extraction department includes the solvent extraction, oil and meal desolventizing, toasting, and cooling equipment. Some equipment is self-supporting, other equipment is supported from steel members which are part of the building with open steel grating providing flooring.

In mills above 500 TPD, equipment was provided for two parallel flows of material through the extraction and meal desolventizing operations.

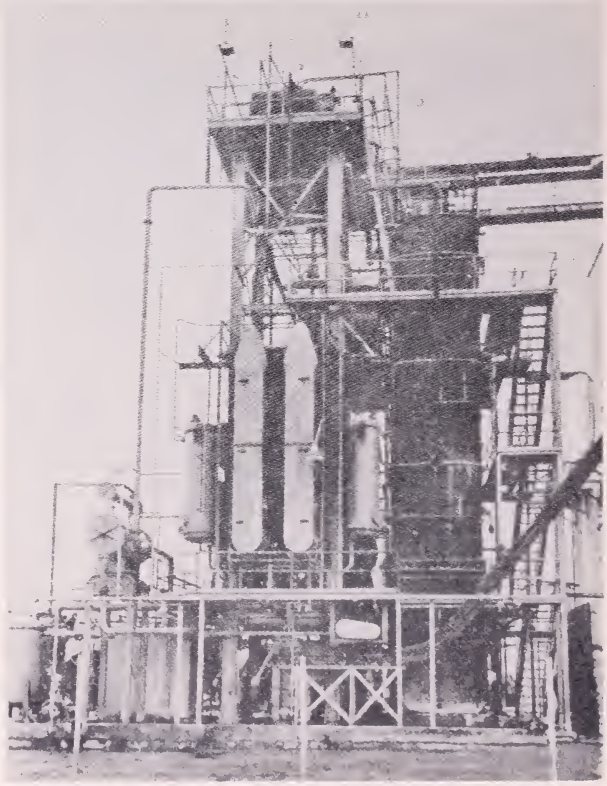


FIGURE 28.—Another type of unhoused solvent extraction plant.

TABLE 50.—*Investment requirements for buildings and equipment for solvent extraction departments in soybean oil mills, by size of mill, 1952–53 season* [1]

Size of mill	Delivered at—			Installation	Total at Indianapolis, Ind.
	Memphis, Tenn.	Waterloo, Iowa	Indianapolis, Ind.		
Tons per day	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
25	127, 270	127, 120	126, 440	42, 920	169, 360
50	169, 210	168, 980	167, 970	53, 700	221, 670
100	249, 900	249, 560	248, 050	73, 000	321, 050
150	308, 020	307, 580	305, 700	87, 990	393, 690
200	366, 910	366, 360	364, 150	104, 660	468, 810
300	485, 250	484, 530	481, 870	140, 270	622, 140
400	579, 440	578, 550	575, 410	162, 390	737, 800
500	660, 320	659, 140	655, 530	182, 690	838, 220
600	814, 920	813, 670	809, 050	226, 070	1, 035, 120
800	957, 220	955, 760	950, 240	258, 890	1, 209, 130
1,000	1, 086, 260	1, 084, 490	1, 078, 160	287, 350	1, 365, 510

[1] Memphis and Waterloo delivered costs are shown for purposes of comparison only. Installation costs are the same at all points.

Data from Texas Engineering Experiment Station.

However, for oil desolventizing and meal cooling, the material flows were combined. This plan agreed with the design of the preparation departments where parallel flows of material were provided for mills above 500 TPD (fig. 17).

Costs of Solvent Extraction Departments

Costs were estimated for the entire solvent extraction departments and are given in table 50. The costs are approximate averages for plants using different manufacturer's equipment, and therefore costs of building and equipment are not listed separately. The costs in table 50 include all items necessary for complete extraction departments except fire protection equipment which is given in table 77. The major items included are:

(1) Buildings.
(2) Solvent extraction equipment.
(3) Oil desolventizing equipment.
(4) Meal desolventizing equipment.
(5) Meal cooling equipment.
(6) Supporting trestle and conveyors between preparation and extraction buildings for unextracted flakes and cooled meal.
(7) Solvent unloading pump and storage tank.
(8) Towers for cooling condenser water.
(9) Pumps for circulating condenser water.

For percolation-type extractors, inert gas generators for purging the extractor were provided in the costs.

SOYBEAN PREPARATION, OIL EXTRACTION, AND MEAL PROCESSING DEPARTMENTS IN SCREW-PRESS OIL MILLS

In screw-press mills, bean preparation, oil extraction, and meal processing departments were located in one building along with the meal shipping and bagged meal storage departments (figs. 5, 6, 29, 30, and 31). Beans are prepared in the same way as in solvent processing up through the cracking rolls. The cracked beans are not conditioned and flaked, as in solvent mills, but go directly from the cracking rolls to cracked bean dryers and then to the screw presses for oil extraction (figs. 29 through 31). As shown in figure 31, two parallel flows of material were provided through the preparation and oil extraction operations in mills of 16 presses (400 TPD) and larger.

Building for Soybean Preparation, Oil Extraction, and Meal Processing

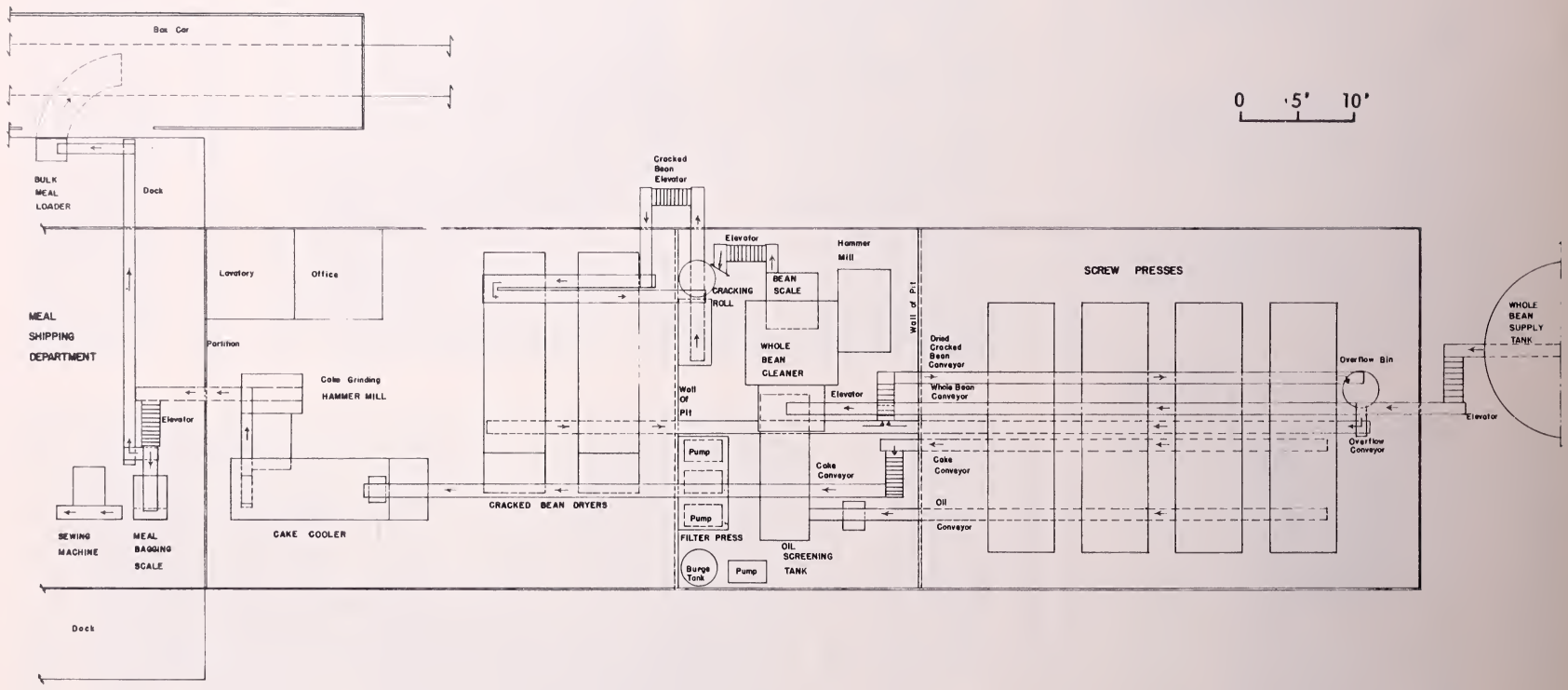
The processing building in screw-press mills is of similar construction and type as the preparation and meal processing building for solvent mills, except that a second floor level is not provided. In this department, costs of operating platforms for dryers and other machinery requiring operating levels above ground floor were grouped with the costs of the machinery instead of being added to the costs of the building. In mills of 16 screw presses (400 TPD size) or more, the sections of the building over the presses are 14 feet to the eaves.

Costs of building sections for bean preparation, oil extraction, and meal processing are given in table 51 for different sizes of mills.

Equipment for Soybean Preparation, Oil Extraction, and Meal Processing

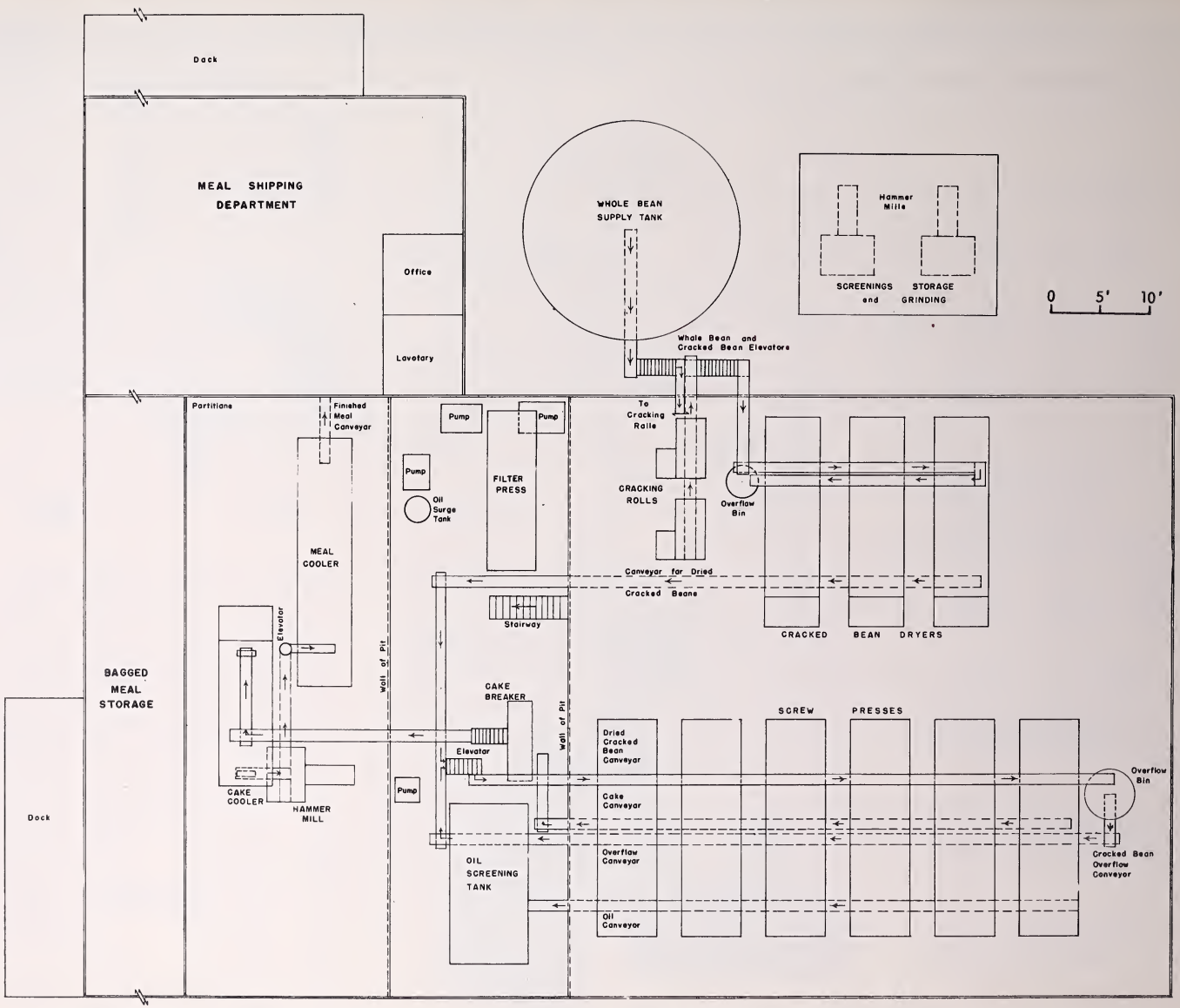
Total costs of equipment for bean preparation, oil extraction, and meal processing are given in table 52. Additional description of machines and number required are given in table 53.

Equipment which differs from that in solvent mills is described in the order of materials flow.



U. S. DEPARTMENT OF AGRICULTURE NEG. 4093-56 (4) AGRICULTURAL MARKETING SERVICE

FIGURE 29.—Soybean preparation, oil extraction, meal processing, and meal shipping departments for a 4-press (100 tons per day) screw-press soybean oil mill. (The 1- and 2- press mills are similar except they are not provided with cake coolers.)



U. S. DEPARTMENT OF AGRICULTURE NEG. 4094-56(4) AGRICULTURAL MARKETING SERVICE

FIGURE 30.—Soybean preparation, oil extraction, and meal processing departments for a 6-press (150 tons per day) screw-press soybean oil mill. (The 8- and 12-press mills are similar.)

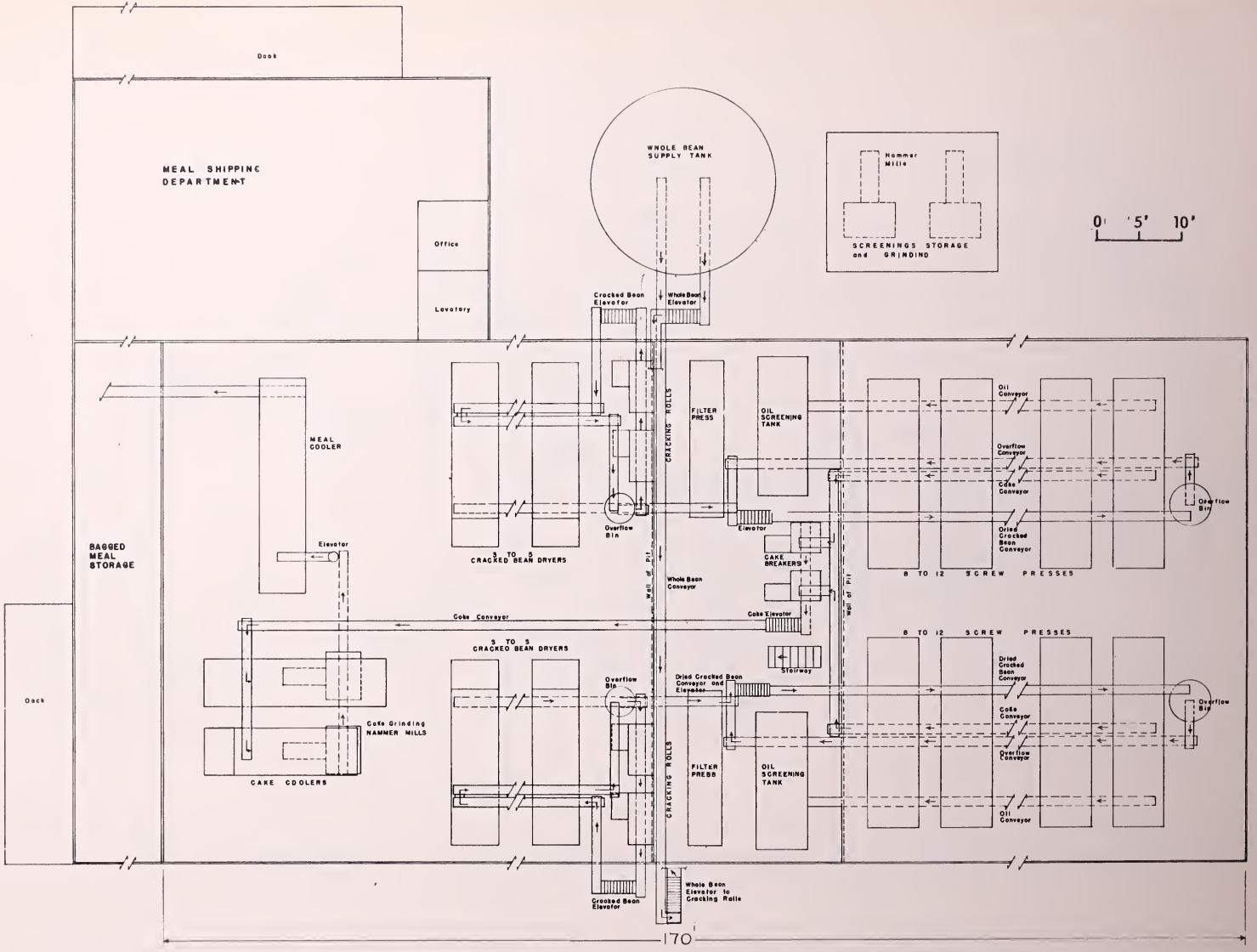


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FIGURE 31.—Soybean preparation, oil extraction, and meal processing departments for 16- through 24-press (400 through 600 tons per day) screw-press soybean oil mills. (These mills are all alike except for number of dryers and presses. Two parallel flows of material through preparation and oil extraction are provided. The 32-press mill is similar.)

TABLE 51.—*Description and investment requirements of building sections for bean preparation, oil extraction, and meal processing in screw-press soybean oil mills, by size of mill, 1952–53 season*

Size of mill	Description		Cost		
	Dimension	Area	Delivered	Installation	Total
Tons per day	*Feet*	*Square feet*	*Dollars*	*Dollars*	*Dollars*
25	60 by 32	1, 920	12, 070	5, 480	17, 550
50	80 by 32	2, 560	15, 120	6, 820	21, 940
100	110 by 32	3, 520	21, 450	9, 540	30, 990
150	100 by 60	6, 000	28, 540	12, 160	40, 700
200	120 by 60	7, 200	32, 520	13, 750	46, 270
300	160 by 60	9, 600	40, 760	17, 260	58, 020
400	170 by 60	10, 200	44, 860	19, 740	64, 600
500	200 by 60	12, 000	51, 100	22, 360	73, 460
600	220 by 60	13, 200	56, 720	25, 140	81, 860
800	290 by 60	17, 400	72, 530	31, 630	104, 160

Data from Texas Engineering Experiment Station.

CRACKED BEAN DRYER AND SCREW PRESS. Before they are ready to be pressed in screw presses, cracked soybeans must be heated and dried. One type of equipment performing this operation is the horizontal conditioner described under solvent preparation equipment. From the dryer the beans are conveyed to the screw presses, where they are given a short additional heating in a steam-jacketed screw conveyor or in stacked kettles. Sometimes all heating and drying is done in vessels or stacked kettles mounted directly over the press. However, this type of equipment did not happen to be selected for this study.

A screw press is a machine with a screw revolving inside a cylindrical cage made of closely spaced steel bars. The screw squeezes the beans against the cage, pressing the oil out between the bars, and advances the pressed cake to the discharge at one end of the cage. Some presses have only a horizontal screw; others have both vertical and horizontal screws and cages operating in series with each other.

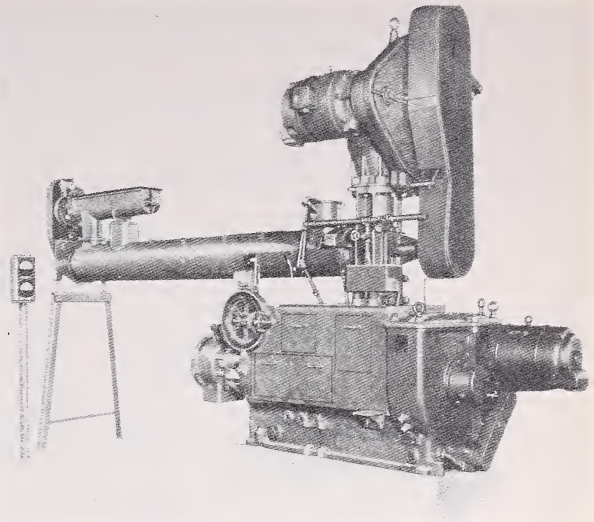

FIGURE 33.—Screw press.

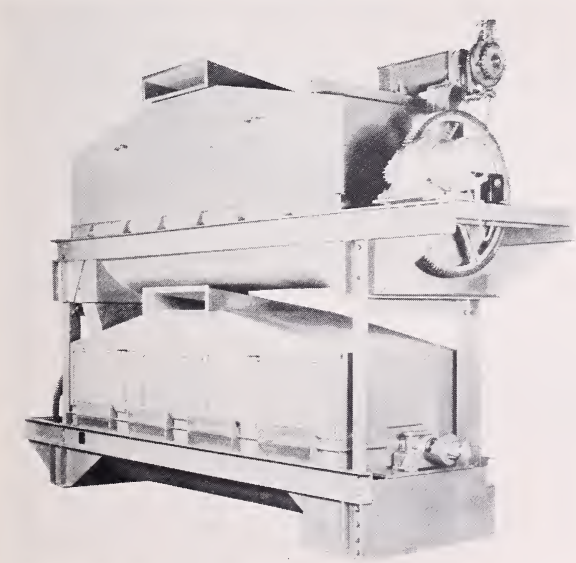

FIGURE 32.—Two-high cracked bean dryer.

OIL-HANDLING EQUIPMENT. Oil-handling equipment includes screenings tanks for separating oil from meal, a filter press for filtering the oil, and tanks and pumps for receiving and pumping both filtered and unfiltered oil.

CAKE GRINDING MILLS. Cake is discharged from screw presses in large pieces. These are first broken into smaller pieces which are partially cooled and then are ground into meal by hammer mills. The category of cake grinding mills includes cake breakers and hammer mills, and auxiliary equipment such as motors for each.

CAKE AND MEAL COOLERS. An increase in moisture and a decrease in temperature of the broken cake are necessary before it is converted into finished meal. The cake is sprayed with water, some of which evaporates, removing heat. The cake can be sprayed in a conveyor; in a cooler

TABLE 52.—*Investment requirements for equipment for soybean preparation, oil extraction, and meal processing in screw-press soybean oil mills, by size of mill, 1952–53 season*

Equipment group	Size of mill (tons per day)														
	25			50			100			150			200		
	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Whole soybean conveyor from storage										11,280	5,010	16,290	11,280	5,010	16,290
Whole soybean supply tank	3,390	1,450	4,840	3,390	1,450	4,840	4,260	1,830	6,090	4,410	2,250	6,660	4,410	2,250	6,660
Soybean cleaner and scale	6,340	2,630	8,970	6,670	2,710	9,380	7,440	2,920	10,360						
Whole soybean scales										1,220	340	1,560	1,220	340	1,560
Cracking rolls	3,920	1,120	5,040	5,730	1,670	7,400	8,630	2,520	11,150	11,460	3,340	14,800	17,270	5,030	22,300
Cracked soybean dryer and screw press	30,640	10,490	41,130	55,880	18,790	74,670	111,750	37,580	149,330	167,630	56,370	224,000	223,500	75,160	298,660
Oil handling equipment	13,280	4,580	17,860	13,280	4,580	17,860	15,720	5,300	21,020	19,360	6,640	26,000	21,160	7,090	28,250
Cake grinding mills	3,860	1,140	5,000	4,090	1,210	5,300	4,090	1,210	5,300	5,850	2,080	7,930	7,730	2,650	10,380
Cake and meal coolers							4,990	1,830	6,820	20,410	6,000	26,410	28,770	8,510	37,280
Cooling water system							2,630	880	3,510	4,010	1,340	5,350	4,950	1,650	6,600
Conveyors	6,150	1,900	8,050	6,060	1,930	7,990	8,220	2,720	10,940	11,950	3,820	15,770	11,990	3,830	15,820
Elevators	10,370	3,110	13,480	10,370	3,110	13,480	10,370	3,110	13,480	11,150	3,200	14,350	11,590	3,320	14,910
Electric power distribution	1,300	400	1,700	1,650	590	2,240	3,300	1,170	4,470	3,300	1,170	4,470	4,950	1,960	6,910
Miscellaneous materials and equip	5,800	1,790	7,590	5,800	1,790	7,590	6,550	2,180	8,730	7,310	2,330	9,640	8,340	2,780	11,120
Facilities for storage and grinding of soybean screenings										9,360	3,060	12,420	9,870	3,205	13,075
Total cost of equipment:															
Indianapolis, Ind.[1]	85,050	28,610	113,660	112,920	37,830	150,750	187,950	63,250	251,200	288,700	96,950	385,650	367,030	122,785	489,815
Memphis, Tenn	85,500	28,610	114,110	113,560	37,830	151,390	189,350	63,250	252,600	290,490	96,950	387,440	369,110	122,785	491,895
Waterloo, Iowa	85,280	28,610	113,890	113,250	37,830	151,080	188,620	63,250	251,870	289,650	96,950	386,600	368,350	122,785	491,135

Equipment group	Size of mill (tons per day)														
	300			400			500			600			800		
	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total	Delivered	Installation	Total
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Whole soybean conveyor from storage	11,280	5,010	16,290	19,520	7,480	27,000	19,520	7,480	27,000	19,520	7,480	27,000	19,520	7,480	27,000
Whole soybean supply tank	4,410	2,250	6,660	5,980	2,600	8,580	5,980	2,600	8,580	5,980	2,600	8,580	5,980	2,600	8,580
Soybean cleaner and scale															
Whole soybean scales	1,220	340	1,560	2,440	680	3,120	2,440	680	3,120	2,440	680	3,120	2,440	680	3,120
Cracking rolls	25,900	7,550	33,450	34,540	10,060	44,600	51,800	15,100	66,900	51,800	15,100	66,900	69,070	20,130	89,200
Cracked soybean dryer and screw press	35,250	112,740	447,990	412,570	136,550	549,120	524,320	174,120	698,440	636,070	211,710	847,780	825,140	273,090	1,098,230
Oil handling equipment	31,680	12,440	44,120	38,730	13,280	52,010	59,780	23,990	83,770	63,360	24,890	88,250	75,490	28,380	103,870
Cake grinding mills	16,720	4,800	21,520	19,460	5,410	24,870	22,600	6,290	28,890	28,700	7,930	36,630	30,800	8,810	39,610
Cake and meal coolers	35,350	10,250	45,600	45,640	14,300	59,940	46,640	13,600	60,240	51,980	15,350	67,330	58,300	17,060	75,360
Cooling water system	6,580	2,190	8,770	7,880	2,630	10,510	9,300	3,100	12,400	10,690	3,560	14,250	13,130	4,380	17,510
Conveyors	13,300	4,300	17,600	17,290	5,490	22,780	21,620	6,690	28,310	21,930	6,530	28,460	31,010	10,050	41,060
Elevators	12,080	3,530	15,610	18,060	5,340	23,400	20,980	6,090	27,070	21,260	6,180	27,440	21,960	6,450	28,410
Electric power distribution	6,600	2,340	8,940	8,250	2,930	11,180	9,900	3,510	13,410	11,550	5,000	16,550	14,850	5,270	20,120
Miscellaneous materials and equip	8,450	2,820	11,270	12,360	5,130	17,490	12,730	5,300	18,030	13,420	5,340	18,760	13,700	5,450	19,150
Facilities for storage and grinding of soybean screenings	17,020	5,355	22,375	17,310	5,425	22,735	20,165	6,205	26,370	21,830	6,580	28,410	25,190	7,495	32,685
Total cost of equipment:															
Indianapolis, Ind.[1]	25,840	175,915	701,755	660,030	217,305	877,335	827,775	274,755	1,102,530	960,530	318,930	1,279,460	1,206,580	397,325	1,603,905
Memphis, Tenn	28,990	175,915	704,905	664,240	217,305	881,545	832,910	274,755	1,107,665	966,400	318,930	1,285,330	1,213,785	397,325	1,611,110
Waterloo, Iowa	27,940	175,915	703,855	662,420	217,305	879,725	830,790	274,755	1,105,545	964,285	318,930	1,283,215	1,211,210	397,325	1,608,535

[1] Indianapolis, Ind., was used as the price basing point for individual items. Differences from the Indiana totals at the other price basing points were owing to differences in delivered cost of machinery.

Data from Texas Engineering Experiment Station.

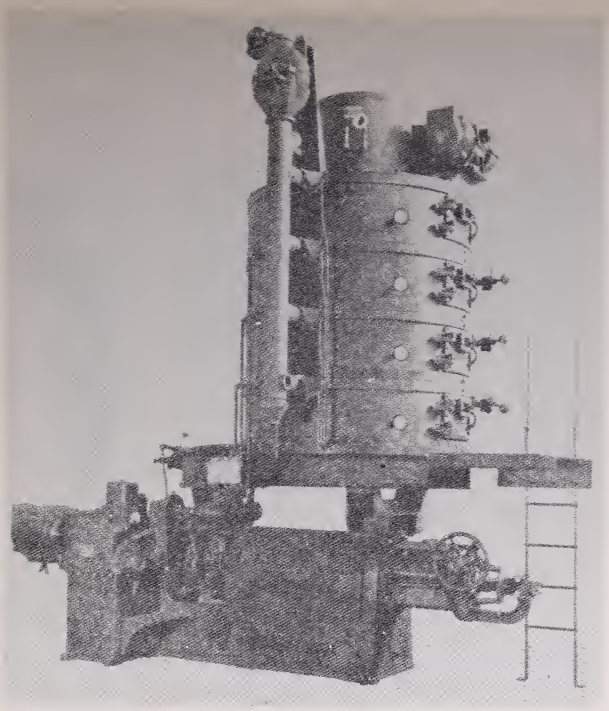

FIGURE 34.—Screw press.

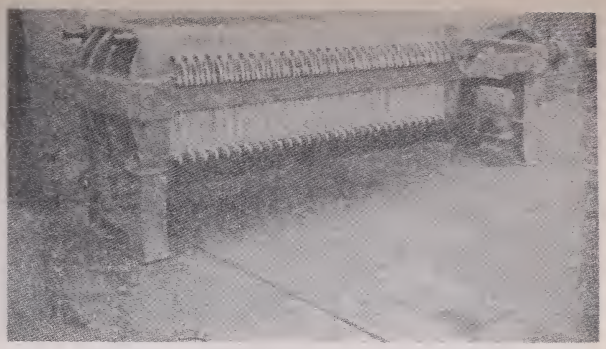

FIGURE 35.—Filter press for filtering oil.

the cake is tumbled about in a stream of air. Cake coolers may be of the same general form as cracked bean dryers, without the steam heated tubes.

Because the design included storage of meal in bulk form in tanks, water-cooled meal coolers were also included in the design to cool ground meal before storage.

COOLING WATER SYSTEM. Frictional heat is developed in a screw press, some of which must be removed by a cooling system. To effect economy in the use of water, cooling towers were provided in all mills except the two smallest to dissipate the

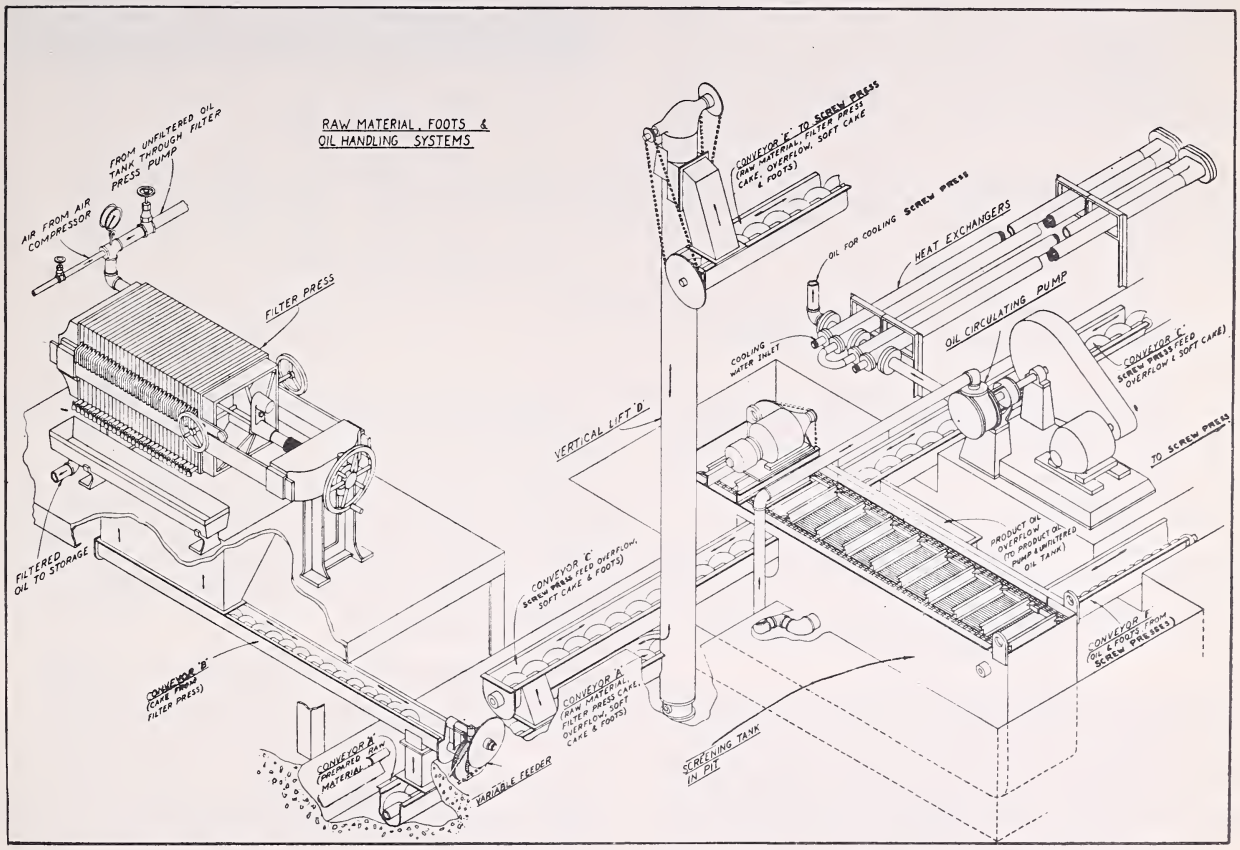
RAW MATERIAL, FOOTS & OIL HANDLING SYSTEMS
FROM UNFILTERED OIL TANK THROUGH FILTER PRESS PUMP
AIR FROM AIR COMPRESSOR
FILTER PRESS
FILTERED OIL TO STORAGE
CONVEYOR 'B' (CAKE FROM FILTER PRESS)
CONVEYOR 'A' (RAW MATERIAL, FILTER PRESS CAKE, OVERFLOW, SOFT CAKE & FOOTS)
CONVEYOR 'C' SCREW PRESS FEED OVERFLOW, SOFT CAKE & FOOTS)
VERTICAL LIFT 'D'
VARIABLE FEEDER
SCREENING TANK IN PIT
CONVEYOR 'E' TO SCREW PRESS (RAW MATERIAL, FILTER PRESS CAKE, OVERFLOW, SOFT CAKE)
OIL FOR COOLING SCREW PRESS
HEAT EXCHANGERS
OIL CIRCULATING PUMP
COOLING WATER INLET
CONVEYOR 'C' SCREW PRESS FEED OVERFLOW & SOFT CAKE)
TO SCREW PRESS
PRODUCT OIL OVERFLOW (TO PRODUCT OIL PUMP & UNFILTERED OIL TANK)
CONVEYOR 'F' (OIL & FOOTS FROM SCREW PRESSES)

FIGURE 36.—Sketch of conveyor's, screenings tank, and filter press for screw-press oil-extraction process.

TABLE 53.—*Number of principal machines required for soybean preparation, oil extraction, and meal processing of screw-press mills, by size of mill* [1]

Machine	Approximate maximum rate per day	Size of mill (tons)									
		25	50	100	150	200	300	400	500	600	800
	Tons	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Soybean cleaner	41	1									
Soybean cleaner	82		1								
Soybean cleaner	125			1							
Hammer mill for grinding cleanings from soybeans		1	1	1							
Whole soybean scale:											
2 bushel	170	1	1	1							
6 bushel	1, 200				1	1	1	2	2	2	2
Cracking roll:											
2 high, 10″ x 24″	43	1									
2 high, 10″ x 42″	100		1		2						
3 high, 10″ x 42″	150			1		2	3	4	6	6	8
Cracked soybean dryer:											
2 high	55	1									
3 high	85		1	2	3	4	6	6	8	10	12
Oil screening tank:											
Small	125	1	1	1							
Medium	250				1	1		2			4
Large	375						1		2	2	
Filter press:											
24, 24″ plates		1	1								
36, 36″ plates				1	1			2	2		
42, 42″ plates						1	1			2	2
Oil holding tank:											
1,800 gallon		3	3	3							
3,600 gallon					3	3		6			
7,200 gallon							3		6	6	6
Cake breaker:											
Small					1	2	2				
Medium								2	2		
Large										1	1
Cake grinding hammer mills		1	1	1	1	1	2	2	2	3	3
Cake cooler	200			1	1	2	2	3	3	4	5
Meal cooler					1	1	1	1	1	1	1
Water cooling tower				1	1	1	1	1	1	1	1

[1] Costs of these machines are included in costs given in table 52.

Data from Texas Engineering Experiment Station.

heat removed from the presses by the cooling system. The cooling water system includes costs of towers for cooling water for both screw presses and meal coolers. This category also includes piping and pumps.

The equipment in other categories in table 14 has the same purpose and description as that described under flake preparation for solvent mills.

PRODUCT STORAGE AND SHIPPING DEPARTMENTS

Soybean oil mills provide storage and shipping departments for soybean oil and soybean meal. The facilities for oil storage and shipping are shown in figures 5–8 and for meal in figures 38–40.

MEAL STORAGE AND SHIPPING DEPARTMENTS

As soybean meal is produced in two main forms—bulk and bagged—meal storage facilities were estimated assuming (1) the usual proportions of bagged and bulk meal (as shown in table 16), and (2) bulk meal only.

Meal storage and shipping departments are described in terms of (1) the meal shipping building and railroad track shed; (2) storage requirements for meal; (3) bagged meal storage building; (4) equipment for meal storage, bagging, and shipping; and (5) total costs for meal storage and shipping departments.

Meal Shipping Buildings and Railroad Track Sheds

Meal shipping buildings were provided in 3 sizes for solvent mills and in 2 sizes for screw-press mills. Description and costs of these buildings are given in table 54. As previously stated, the meal shipping building was designed as a section of the processing building (figs. 5–8) and is therefore of the same construction. The costs given in table 54 include costs of partitions to separate

meal bagging, which is done in the shipping department, from meal processing. These partitions are of the same construction as the building (steel frame, iron clad). Separation of these departments by partitions is recommended by some fire protection authorities. Separation is also necessary because shipping is done in an unheated area, while processing is performed in a heated area with wet pipe sprinklers for fire protection.

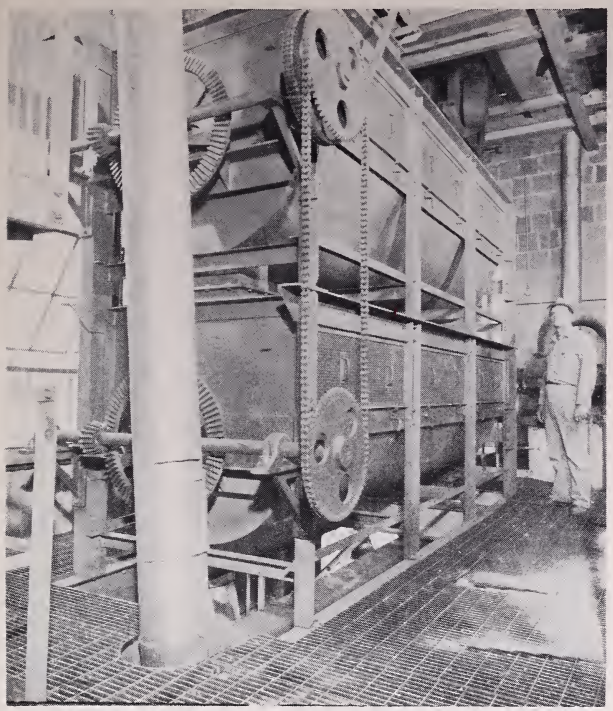

FIGURE 37.—Two-high cake or meal cooler installed in a mill.

Railroad track sheds were provided for all mills of 300 TPD and larger to shelter 2 tracks adjacent to the meal shipping department. Sheds 40 feet long were provided for mills with 1 bulk meal loader and 100 feet long for 2 bulk loaders. The selection of bulk loaders is discussed later and shown in tables 58 and 59.

Storage Requirements for Soybean Meal

For purposes of orderly marketing, storage capacity equivalent to 5 days' meal production was provided for mills of sizes 100 TPD and under, 4 days' for 150- and 200-TPD mills, and 3 days' for larger mills. This includes requirements for both bagged and bulk meal. Based on the average meal yield of solvent and screw-press mills as given in table 3, and the number of days' meal production assumed to be stored, the meal storage requirements were calculated and are shown in table 55.

Bagged Meal Storage Buildings

Bagged meal storage buildings (figs. 38–40) were designed and their costs estimated in terms of building bays 10 feet long which could be added to one end of the processing building. By this method storage space could be varied easily.

Each width of processing building has a meal storage bay cost unit. The 4 widths of bays (32,

TABLE 54.—*Description and investment requirements for building sections and railroad track sheds for meal shipping in soybean oil mills, by type and size of mill, 1952–53 season* [1]

Type and size of mill	Meal shipping building section					Railroad track shed					Total cost
	Description		Cost			Description		Cost			
	Dimensions	Area	Delivered	Installation	Total	Dimensions	Area sheltered	Delivered	Installation	Total	
Tons per day	*Feet*	*Square feet*	*Dollars*	*Dollars*	*Dollars*	*Feet*	*Square feet*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Solvent:											
25–100	20 by 38	760	5,580	2,710	8,290						8,290
150–200	40 by 38	1,520	9,220	4,450	13,670						13,670
300–400	30 by 52	1,560	10,770	5,060	15,830	40 by 34	1,360	3,500	1,720	5,220	[2] 21,050
500–1,000	30 by 52	1,560	10,770	5,060	15,830	100 by 34	3,400	7,150	3,700	10,850	26,680
Screw press:											
25–100	20 by 32	640	5,640	2,840	8,480						8,480
150–200	30 by 60	1,800	13,560	5,900	19,460						19,460
300–400	30 by 60	1,800	13,560	5,900	19,460	40 by 34	1,360	3,500	1,720	5,220	[2] 24,680
500–800	30 by 60	1,800	13,560	5,900	19,460	100 by 34	3,400	7,150	3,700	10,850	30,310

[1] Applies for mills shipping bagged and bulk meal as well as for mills shipping only bulk meal except for the 400-ton-per-day mills which use the 100-foot shed when shipping only bulk meal.

[2] Applies to the 400-ton-per-day mill when shipping both bagged and bulk meal. When shipping only bulk meal the 100-foot shed is used and the total cost is $26,680 for the 400-ton-per-day solvent mill and $30,310 for the 400-ton-per-day screw-press mill.

Data from Texas Engineering Experiment Station.

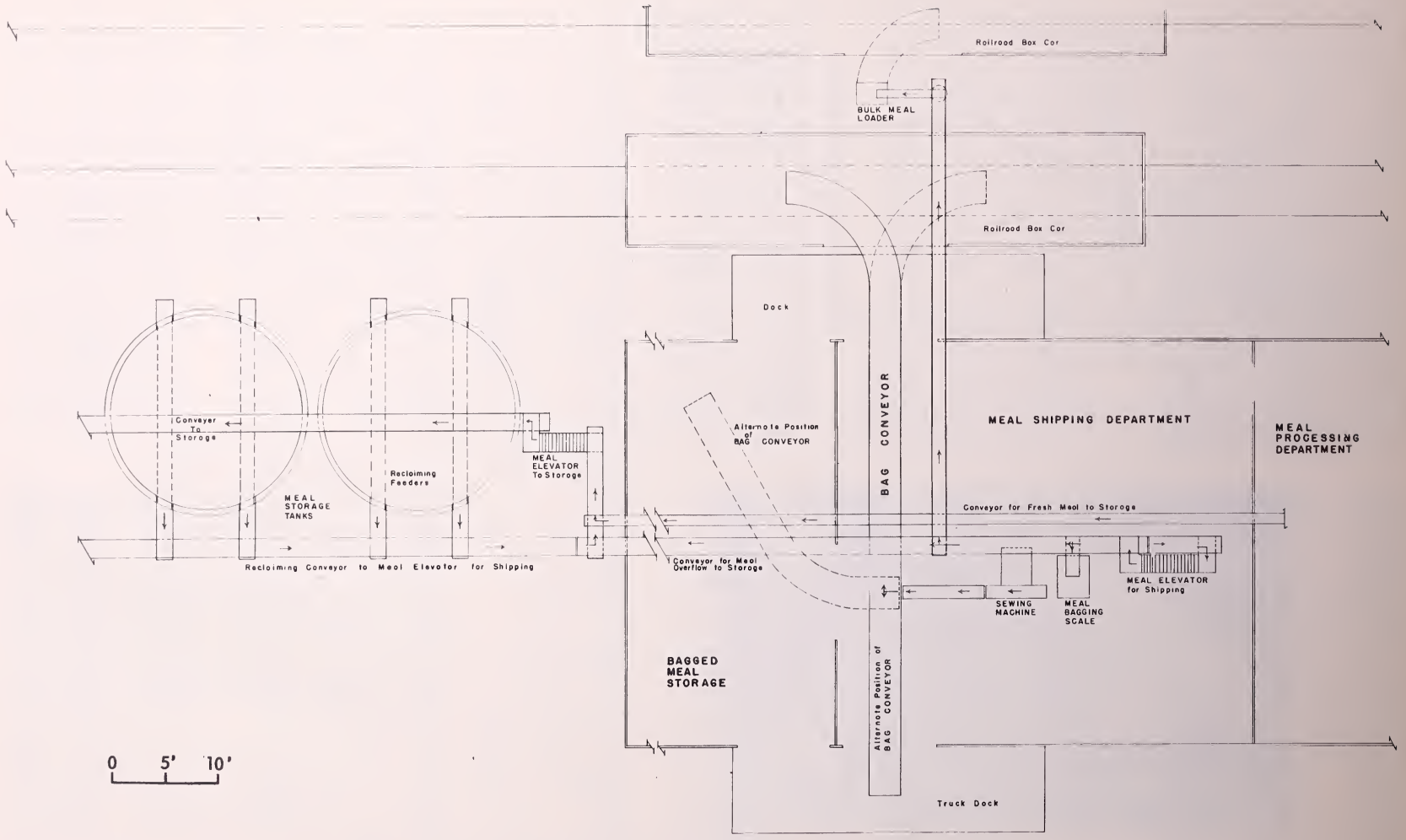

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FIGURE 38.—Meal shipping department for a 100- or 200-ton-per-day solvent soybean oil mill with 165-ton meal tanks. This layout is for mills with 38-foot-wide buildings and meal shipping department located on the end of the building. Both meal bagging scales and bulk meal loader are shown.

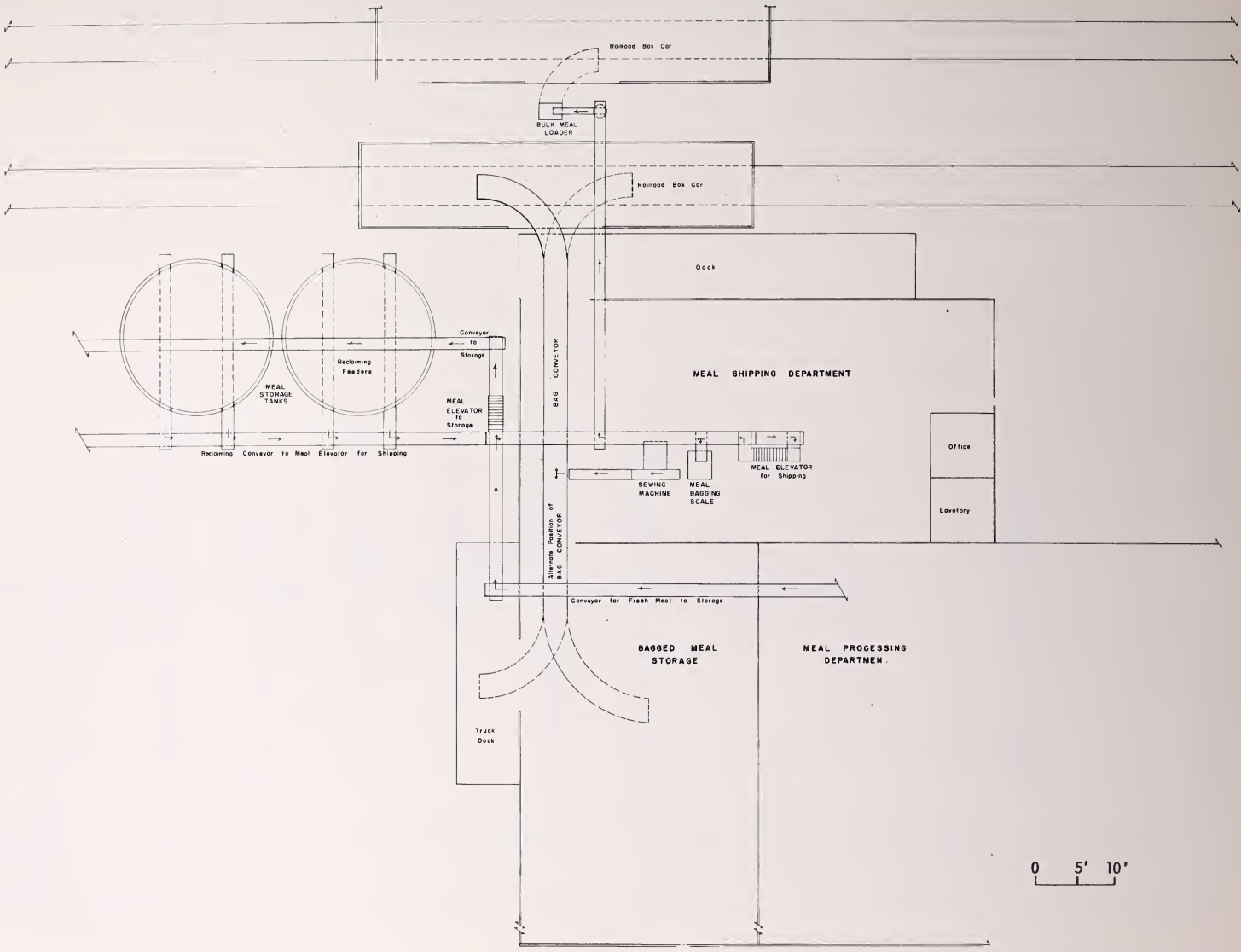

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FIGURE 39.—Meal shipping department for a screw-press or solvent soybean oil mill with 165-ton meal tanks. This layout is for mills with 52- or 60-foot-wide buildings and meal shipping department located on the side of the main building. Both meal bagging scales and bulk meal loader are shown.

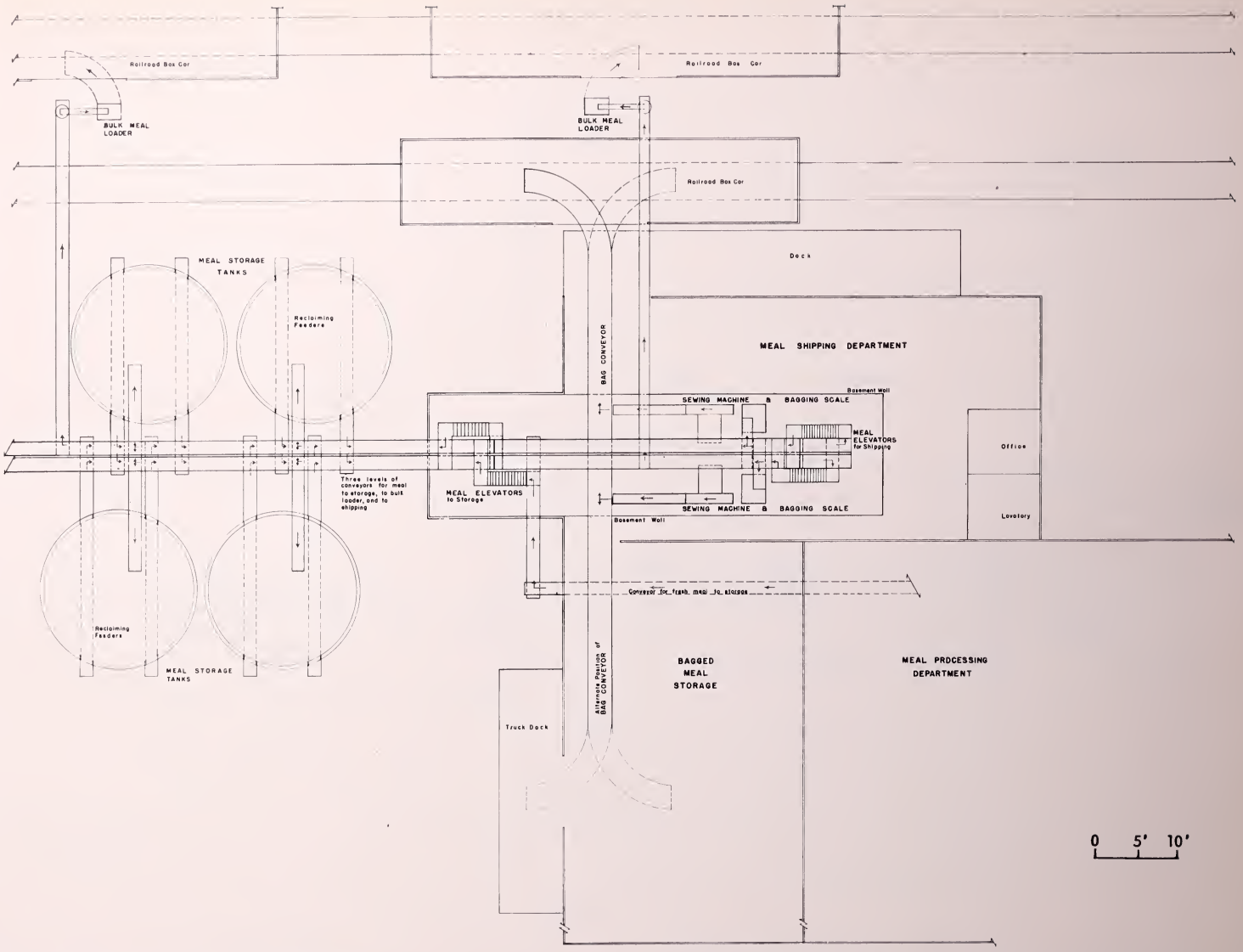

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FIGURE 40.—Meal shipping department for a screw-press or solvent soybean oil mill with 250-ton meal tanks. This layout provides parallel facilities for meal shipping in large mills with elevators and conveyors to serve 2 bulk meal loaders and 2 meal bagging scales operating simultaneously. For bulk meal shipping only, building requirements would be as shown, but bagged meal handling facilities would be removed.

TABLE 55.—*Soybean meal storage requirements for soybean oil mills producing bagged and bulk meal, by type and size of mill*

Type and size of mill	Total meal storage required [1]	Storage provided for [2]				10-foot bagged meal storage bays [4]					Bulk meal tanks [6]		
		Bulk meal	Bagged meal			Width	Capacity with bags stacked		Provided		Provided	Size	Total capacity
			Meal	Bales of bags [3]	Total		15 feet high [5]	6 feet high	Amount	Total capacity			
Tons per day	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Feet*	*Tons*	*Tons*	*Number*	*Tons*	*Number*	*Tons*	*Tons*
Solvent:													
25	100	---	100	90	190	38	65	---	3	195	---	---	---
50	200	---	200	90	290	38	65	---	5	325	---	---	---
100	410	---	410	90	500	38	65	---	8	520	---	---	---
150	490	440	50	90	140	38	---	40	4	140	3	165	495
200	650	610	50	90	140	38	---	40	4	140	4	165	660
300	740	690	50	180	230	52	---	55	4	220	5	165	825
400	980	930	50	180	230	52	---	55	4	220	6	165	990
500	1, 230	1, 180	50	180	230	52	---	55	4	220	7	165	1, 155
600	1, 470	1, 420	50	180	230	52	---	55	4	220	6	250	1, 500
800	1, 960	1, 910	50	180	230	52	---	55	4	220	8	250	2, 000
1,000	2, 450	2, 400	50	180	230	52	---	55	4	220	10	250	2, 500
Screw press:													
25	100	---	100	90	190	32	50	---	4	200	---	---	---
50	200	---	200	90	290	32	50	---	6	300	---	---	---
100	410	---	410	90	500	32	50	---	10	500	---	---	---
150	490	440	50	90	140	60	---	63	3	189	3	165	495
200	650	610	50	90	140	60	---	63	3	189	4	165	660
300	740	690	50	180	230	60	---	63	4	252	5	165	825
400	980	930	50	180	230	60	---	63	4	252	6	165	990
500	1, 230	1, 180	50	180	230	60	---	63	4	252	5	250	1, 250
600	1, 470	1, 420	50	180	230	60	---	63	4	252	6	250	1, 500
800	1, 960	1, 910	50	180	230	60	---	63	4	252	8	250	2, 000

[1] Equivalent to 5 days' meal production for mills 100 tons per day and under; 4 days for 150- and 200-ton-per-day mills; and 3 days for larger mills.

[2] See pp. 69, 75.

[3] Bales of bags equivalent to tons of bagged meal are stored in bagged meal warehouse along with bagged meal.

[4] The bagged meal storage building is a continuation of the meal processing building. Description and investment requirements for the bagged meal storage buildings are given in table 56.

[5] Only the mills provided with fork trucks are able to stack bags 15 feet high.

[6] Description and investment requirements of bulk meal tanks are given in table 58.

TABLE 56.—*Description and investment requirements for building sections for bagged meal storage in soybean oil mills, by type and size of mill, 1952–53 season*

Type and size of mill	10-foot bay of storage space						Building partition cost		Building section				
	Description				Cost				Description		Cost		
	Width	Area	Storage capacity for bags stacked [1]		Delivered	Installation	Delivered	Installation	10-foot bays provided [1]	Area	10-foot bays [2]	Partition	Total
			15 feet high	6 feet high									
Tons per day	*Feet*	*Square feet*	*Tons*	*Tons*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Square feet*	*Dollars*	*Dollars*	*Dollars*
Solvent:													
25	38	380	65	----------	1, 470	590	----------	----------	3	1, 140	6, 180	----------	6, 180
50	38	380	65	----------	1, 470	590	----------	----------	5	1, 900	10, 300	----------	10, 300
100	38	380	65	----------	1, 470	590	1, 360	440	8	3, 040	16, 480	1, 800	18, 280
150–200	38	380	----------	40	1, 470	590	1, 360	440	4	1, 520	8, 240	1, 800	10, 040
300–1,000	52	520	----------	55	1, 730	700	1, 910	610	4	2, 080	9, 720	2, 520	12, 240
Screw press:													
25	32	320	50	----------	1, 520	670	----------	----------	4	1, 280	8, 760	----------	8, 760
50	32	320	50	----------	1, 520	670	----------	----------	6	1, 920	13, 140	----------	13, 140
100	32	320	50	----------	1, 520	670	1, 140	360	10	3, 200	21, 900	1, 500	23, 400
150–200	60	600	----------	63	1, 960	790	2, 240	720	3	1, 800	8, 250	2, 960	11, 210
300–800	60	600	----------	63	1, 960	790	2, 240	720	4	2, 400	11, 000	2, 960	13, 960

[1] From table 55.

[2] Equivalent to number of bays provided times cost per bay.

Data from Texas Engineering Experiment Station.

38, 52, and 60 feet) have storage capacities of 50, 65, 95, and 115 tons of meal in bags stacked 15 feet high. Bags would be likely to be stacked 15 feet high only with mechanical stackers such as fork trucks. Only small mills were provided with fork trucks (table 58). In larger mills without fork trucks, bags were assumed to be stacked 6 feet high without aisles, and the capacities of the 32-, 38-, 52-, and 60-foot-wide bays were then 33, 40, 55, and 63 tons of meal.

Bales of meal bags were assumed to be stored in the bagged meal warehouse and to require about 400 to 500 square feet of floor area per railroad carload, depending on the size of car in which the bales were shipped. This is equivalent to about 90 tons of meal storage area. Therefore, storage space was provided for bales of bags equivalent to 90 tons of bagged meal for small mills (200 TPD and under) and 180 tons for large mills (table 55). Although small mills would probably receive bags by truck instead of railroad car, and thus require less space, enough was provided to take care of either type of shipment. The number and sizes of bags required for bagged meal and bales of bags are shown in table 55 for different size mills. Descriptions and costs of the buildings are given in table 56. The building costs include partitions (of the same type as described before) for separating meal bagging operations and bagged meal storage in mills of 100-TPD size and larger.

FIGURE 41.—Fork truck stacking bagged material.

Equipment for Meal Bagging, Storage, and Shipping

Costs of equipment for meal bagging, bulk storage, and shipping are given in table 58. It was assumed that all bagged meal would be bagged as produced in mills up through 100 TPD. In larger mills, meal from production would normally be stored in tanks until bagged or loaded into bulk receivers. This plan was followed in making up the cost-units given in table 58.

Two sizes of steel meal tanks, differing only in height, were designed to contain 165 and 250 tons of meal. Each tank was provided with two feeders under it to convey meal from the tank into a conveyor to the meal shipping department. The tanks received meal from conveyors running across the tops. The 165- and 250-ton tanks were designed to be installed in single and double rows, respectively, as shown in figures 38, 39, and 40.

Because meal tanks differed in height and in layout, elevator and conveyor costs groups were designed to go with installations of each size of tanks. Tanks of both sizes were not used in the same mill.

For sizing the conveyors and elevators bringing bulk meal from storage to meal shipping, a bulk loader was assumed to require a maximum of 50 tons per hour and a bagging scale a maximum of 25 tons per hour. These assumptions were used in designing the elevating and conveying equipment for the 2 sizes of tanks (table 57).

Conveyors and elevators for 250-ton tanks are duplicate facilities of the same size (except for elevator height) and layout as provided for 165-ton tanks.

Bag conveyors were designed to extend into boxcars, into trucks at the dock opposite bagged meal warehouse, or into the bagged meal warehouse. These conveyors could convey bags from bagging scales into any one of these receivers and it could also carry bags from storage to truck or boxcar.

Bulk meal loaders are of the type that have a moving belt which imparts sufficient momentum

TABLE 57.—*Capacities of elevator and conveyor cost-groups serving meal tanks*

Elevators and conveyors for—	Conveyor and elevator capacity	Bagging scales served	Bulk loaders served	Meal shipping units which can be operated simultaneously	
				Scales	Loader
	Tons per hr.	*Number*	*Number*	*Number*	*Number*
1 bulk loader with 165-ton tank	50	2	1		
2 bulk loaders with 165-ton tank	100	2+	2	2	1
250-ton tanks	200	2+	2	2+	2

Data from Texas Engineering Experiment Station.

FIGURE 42.—Steel tanks such as those which were provided for meal storage.

to carry the meal through the air from the discharge of the loader into the ends of boxcars. Costs include conveyor feeding the moving belt and other accessory equipment.

Also included in table 58 are costs of screw conveyors to carry finished meal through the bagged meal storage section to the meal tanks as shown in figures 38–40.

The other titles for cost units in table 58 are self-explanatory.

The selection of bagging scales and bulk meal loaders determined the selection of the other meal shipping facilities and the size of bulk meal storage tanks.

For an average bagging operation, a rate of 100 tons of meal per 8-hour shift was selected. Assuming all meal is shipped during not more than 16 hours of bagging per day for 5 days a week, and assuming all meal produced is bagged, the

FIGURE 43.—Conveyor carrying loaded bags into a boxcar for shipping.

maximum size of mill which one bagging scale will serve is given in the following calculation:

$$\frac{100 \text{ tons} \times 2 \text{ shifts} \times 5 \text{ days}}{7 \text{ days} \times 0.816 \text{ tons meal per ton of beans}} = 175 \text{ TPD}$$

Depending upon the proportion of meal shipped in bulk, one bagging scale will be sufficient for somewhat larger mills. For example, if only 25

FIGURE 44.—Belt thrower loading bulk meal into boxcar.

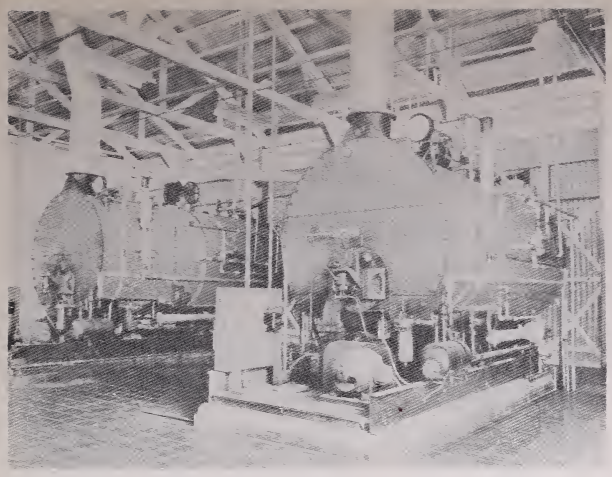

FIGURE 45.—Two 300-horsepower boilers installed in a boilerhouse in a type of installation similar to that designed for this study.

percent of the meal is shipped in bags (75 percent in bulk), one scale will serve $\frac{175}{0.25}$=700 TPD.

If operation on 1 instead of 2 shifts per day, 5 days per week is desired, the capacity of a bagging scale will be one-half of that given above. For all mills except the 800- and 1,000-TPD sizes, bagging scales were specified on the latter basis in order to provide capacity sufficient to take care of large orders for bagged meal.

For bulk loading, an average rate of 260 tons of meal per 8 hour shift per loader was estimated. For 100 percent of meal shipped in bulk, and if loading is carried on during only 80 working hours per week, the maximum size of mill which can be served by one loader is $\frac{260\times2\times5}{7\times0.816}$=456 TPD. If only 75 percent of all meal is shipped in bulk, 1 loader will serve 600 TPD.

No provision was made in the design for more than two bulk loaders. Loading of more than 2,600 tons per week in the largest mills could be accomplished with two loaders by operating more than 80 hours per week or at a higher average hourly rate.

After the numbers of bagging scales and bulk loaders were determined, the sizes of meal tanks and associated elevating and conveying units were selected from the tabulation above which was used to explain the sizing of meal shipping conveyors. For example, if 1 scale and 1 loader were selected and they would not have to operate simultaneously, elevators and conveyors for one bulk loader with 165-ton meal tanks would be provided. If 2 scales and 2 loaders were selected, and if they would need to operate simultaneously, elevators and conveyors for 165-ton tanks would be insufficient and elevators and conveyors for 250-ton tanks would need to be provided. Of course, in selecting tanks to provide the storage required, tank sizes to go with the elevators and conveyor units selected would need to be used.

The other equipment needed is self-evident from the titles of the cost units and an inspection of table 58, where all of the units are specified for different sizes of mills.

If mills did not have hopper scales in the elevator workhouse for weighing incoming beans, cost of railroad and track scales for this purpose were included in the costs of the elevator department (table 45). (These scales would also be used to weigh oil and meal shipped.) In mills with hopper scales, railroad track scales are added to the costs of the meal shipping department. These scales will also weigh oil except in the large mills where oil tank scales are provided. Track scales provided in mills with hopper scales were added to the costs of meal storage and shipping department and are shown in tables 58 and 59.

SOYBEAN OIL STORAGE AND SHIPPING FACILITIES

Soybean oil is commonly stored in ordinary steel tanks until it is pumped into tank cars for shipping. Occasionally tanks must be cleaned, and for this reason at least two tanks were provided for all except the two smallest mills. Units were made up for three 2-tank units, and for one single-tank unit to be used along with one of the 2-tank units. Costs include tank, foundation, manifold piping connecting the tank, and fire protection dike around the tanks. Costs are shown in table 62. Also shown are costs of pumps for pumping oil to tank cars, and a scale tank and housing for weighing oil before loading in large mills. Tank scales were provided largely on the basis of judgment as to the size of mill in which one railroad track scale could no longer handle weighing of both meal and oil, and tank scales were added for all mills beyond this point.

The minimum amount of oil storage necessary for orderly operations was estimated to be equivalent to 7 days' oil production. Facilities provided in table 62 were based on this figure.

SERVICE DEPARTMENT

The service department of soybean oil mills is described in terms of the (1) boilerhouse, machine shop, storeroom, and locker rooms; (2) electric power substations; (3) trucks and automobiles; (4) miscellaneous supplies; and (5) inventories of supplies.

BOILERHOUSE, MACHINE SHOP, AND STOREROOM

The building to house the boilers, machine shop, and storeroom is of steel frame with corrugated steel siding. It is 12 feet from foundation to eaves. This building also houses the employees' locker rooms (whose costs are in table 66) and includes space which may be used as an office for supervisors or purchasing agent, or for other purposes. The costs of the building are given in table 63.

TABLE 58.—*Investment requirements for equipment for meal storage, bagging, and shipping in soybean oil mills, by size of mill, 1952–53 season* [1]

Equipment unit	Unit cost			Size of mill (tons per day rate)																					
				25		50		100		150		200		300		400		500		600		800		1,000 [2]	
	Delivered	Installation	Total	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost
	Dollars	*Dollars*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*
Elevators and conveyors for meal bagging in mills without meal tanks	4,900	1,780	6,680	1	6,680	1	6,680	1	6,680																
Elevators and conveyors for bulk meal loader in mills without meal tanks	710	270	980			1	980	1	980																
Meal tank, 165-ton capacity	7,760	4,240	12,000							3	36,000	4	48,000	5	60,000	6	72,000								
Elevators and conveyors for 1 bulk meal loader with 165-ton meal tank	11,000	3,500	14,500							1	14,500	1	14,500												
Elevators and conveyors for 2 bulk meal loaders with 165-ton meal tank	19,660	6,190	25,850											1	25,850	1	25,850								
Meal tank, 250-ton capacity	9,220	4,820	14,040															5	70,200	6	84,240	8	112,320	10	140,400
Elevators and conveyors for 250-ton meal tanks	51,500	16,030	67,530															1	67,530	1	67,530	1	67,530	1	67,530
Elevator house and auxiliary equipment for 250-ton meal tanks	10,140	4,730	14,870															1	14,870	1	14,870	1	14,870	1	14,870
Meal bagging scale	4,510	1,210	5,720	1	5,720	1	5,720	1	5,720	1	5,720	1	5,720	1	5,720	2	11,440	2	11,440	2	11,440	2	11,440	2	11,440
Bulk meal loader	970	300	1,270			1	1,270	1	1,270	1	1,270	1	1,270	1	1,270	1	1,270	2	2,540	2	2,540	2	2,540	2	2,540
Motorized fork truck and pallets	4,730	90	4,820	1	4,820	1	4,820	1	4,820																
Bag conveyors for building:																									
38 feet wide [2]	7,640	450	8,090							1	8,090	1	8,090												
52 feet wide [2]	9,820	550	10,370											1	10,370	1	10,370	1	10,370	1	10,370	1	10,370	1	10,370
60 feet wide [3]	10,320	600	10,920							1	10,920	1	10,920	1	10,920	1	10,920	1	10,920	1	10,920	1	10,920		
Bag conveyor auxiliary equipment	1,620	80	1,700							1	1,700	1	1,700	1	1,700	2	3,400	2	3,400	2	3,400	2	3,400	2	3,400
Additional screw conveyor per 10-foot bay of bagged meal storage building for buildings:																									
38 feet wide [2]	516	279	795							4	3,180	4	3,180												
60 feet wide	83	23	106							3	318	3	318	4	[4] 424	4	[2] 424								
52 feet wide and 60 feet wide [5]	117	32	149													4	[1] 596	4	596	4	596	4	596		
52 feet wide [2]	143	38	181																					4	724
Railroad car spotter	850	290	1,140			1	1,140	1	1,140	1	1,140	1	1,140	1	1,140	1	1,140	2	2,280	2	2,280	2	2,280	2	2,280
Railroad track scales	15,000	5,000	20,000									1	20,000	1	20,000	1	20,000	1	20,000	1	20,000	2	40,000	2	40,000
Total equipment cost for—																									
Solvent mills					17,220		20,610		20,610		103,600		126,474		126,474		146,066		203,226		217,266		265,346		293,554
Screw-press mills					17,220		20,610		20,610		71,568		103,568		127,024		146,444		203,776		217,816		265,896		

[1] Production of bagged and bulk meal.

[2] Solvent mills only.

[3] Screw-press mills only.

[4] Cost for 52-foot-wide solvent building included because its cost is the same as for 60-foot-wide screw-press building.

[5] Costs for 52-foot-wide solvent buildings and 60-foot-wide screw-press buildings are the same except for the 400-ton-per-day mill whose cost is for 52-foot-wide solvent building only.

Data from Texas Engineering Experiment Station.

TABLE 59.—*Investment requirements for equipment for bulk meal storage and shipping in soybean oil mills, by size of mill, 1952–53 season* [1]

Equipment unit	Unit cost	Size of mill (tons per day)																					
		25		50		100		150		200		300		400		500		600		800		1,000	
		Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost
	Dollars	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*
Meal tank, 165 tons capacity	12,000	1	12,000	1	12,000	3	36,000	3	36,000	4	48,000	5	60,000	6	72,000	7	84,000						
Elevators and conveyors for 1 bulk meal loader with 165-ton meal tanks	14,500	1	14,500	1	14,500	1	14,500	1	14,500	1	14,500	1	14,500										
Elevators and conveyors for 2 bulk meal loaders with 165-ton meal tanks	28,850													1	25,850	1	25,850						
Meal tank, 250 tons capacity	14,040																	6	84,240	8	112,320	10	140,400
Elevators and conveyors for 250-ton meal tanks	67,530																	1	67,530	1	67,530	1	67,530
Auxiliary equipment for 250-ton meal tanks	14,870																	1	14,870	1	14,870	1	14,870
Bulk meal loader	1,270	1	1,270	1	1,270	1	1,270	1	1,270	1	1,270	1	1,270	2	2,540	2	2,540	2	2,540	2	2,540	2	2,540
Railroad car spotter	1,140			1	1,140	1	1,140	1	1,140	1	1,140	1	1,140	2	2,280	2	2,280	2	2,280	2	2,280	2	2,280
Railroad track scales	20,000									1	20,000	1	20,000	1	20,000	1	20,000	1	20,000	2	40,000	2	40,000
Total cost of equipmen			27,770		28,910		52,910		52,910		84,910		96,910		122,670		134,670		191,460		239,540		267,620

[1] Assumes production of bulk meal only.

Data from Texas Engineering Experiment Station.

TABLE 60.—*Total investment requirements for building sections and equipment for meal shipping and storage in soybean oil mills producing both bagged and bulk meal, by type and size of mill, 1952–53 season* [1]

Type and size of mill	Meal shipping building section and railroad track shed	Bagged meal storage building section	Equipment	Total
Tons per day				
Solvent:	*Dollars*	*Dollars*	*Dollars*	*Dollars*
25	8, 290	6, 180	17, 220	31, 690
50	8, 290	10, 300	20, 610	39, 200
100	8, 290	18, 280	20, 610	47, 180
150	13, 670	10, 040	71, 600	95, 310
200	13, 670	10, 040	103, 600	127, 310
300	21, 050	12, 240	126, 474	159, 764
400	21, 050	12, 240	146, 066	179, 356
500	26, 680	12, 240	203, 226	242, 146
600	26, 680	12, 240	217, 266	256, 186
800	26, 680	12, 240	265, 346	304, 266
1,000	26, 680	12, 240	293, 554	332, 474
Screw press:				
25	8, 480	8, 760	17, 220	34, 460
50	8, 480	13, 140	20, 610	42, 230
100	8, 480	23, 400	20, 610	52, 490
150	19, 460	11, 210	71, 568	102, 238
200	19, 460	11, 210	103, 568	134, 238
300	24, 680	13, 960	127, 024	165, 664
400	24, 680	13, 960	146, 444	185, 084
500	30, 310	13, 960	203, 776	248, 046
600	30, 310	13, 960	217, 816	262, 086
800	30, 310	13, 960	265, 896	310, 166

[1] Total costs from tables 54, 56, and 58.

Data from Texas Engineering Experiment Station.

Steam-Generating Equipment

The cost of steam-generating equipment (table 64) included the following major items: Factory-assembled or "package type" steam generators, feedwater softeners, feedwater heaters and pumps, instruments and controls, fuel oil storage and pumps, fuel oil heaters, piping, and auxiliary and miscellaneous equipment. Steam generators were equipped with burners to burn either gas or fuel oil. The smaller generators were designed to be fired with No. 2 fuel oil or gas and the large with No. 6 fuel oil or gas.

Standby equipment was provided for all mills, except the two smallest in each type, to allow for repair work on one generator while the other one or two were in operation. For the two smallest mills, only one generator was provided, thus slightly decreasing the investment cost.

Oil- or gas-fired boilers were used instead of coal fired, because "package type" boilers could be employed which simplified the design and cost estimating. Enough actual mills use such boilers to justify their use in this study.

Oil-fired, steam-generating plants are somewhat less costly than coal-fired plants, and they can be instrumented to operate with less supervision. These two factors tend to counteract the higher unit cost of fuel and to bring the unit cost of steam from oil-fired plants close to the cost of steam from coal-fired plants.

For southern mills, possibly gas firing instead of oil firing would be generally used. However, standby oil-firing equipment might be necessary, and the estimation of costs for both types was not considered to be justifiable.

Machine Shop Equipment and Storeroom Supplies

Allowances for machine-shop equipment and storeroom supplies are given in table 65. The costs of machine-shop equipment include estimates for all of the tools and equipment for maintenance and repair work, such as drill presses, lathes, welding machines, workbenches, etc. The storeroom supplies include such items as janitor supplies and office supplies.

These estimates are based on those prepared for the study of cottonseed oil mills,[9] which were made by actually listing and pricing a variety of items. For the current study, the estimates were taken from graphs of cost versus size of mill.

TABLE 61.—*Total investment requirements for building sections and equipment for meal shipping in soybean oil mills producing bulk meal only, by type and size of mill, 1952–53 season* [1]

Type and size of mill	Meal shipping building section and railroad track shed	Equipment	Total
Tons per day			
Solvent:	*Dollars*	*Dollars*	*Dollars*
25	8, 290	27, 770	36, 060
50	8, 290	28, 910	37, 200
100	8, 290	52, 910	61, 200
150	13, 670	52, 910	66, 580
200	13, 670	84, 910	98, 580
300	21, 050	96, 910	117, 960
400	26, 680	122, 670	149, 350
500	26, 680	134, 670	161, 350
600	26, 680	191, 460	218, 140
800	26, 680	239, 540	266, 220
1,000	26, 680	267, 620	294, 300
Screw press:			
25	8, 480	27, 770	36, 250
50	8, 480	28, 910	37, 390
100	8, 480	52, 910	61, 390
150	19, 460	52, 910	72, 370
200	19, 460	84, 910	104, 370
300	24, 680	96, 910	121, 590
400	30, 310	122, 670	152, 980
500	30, 310	134, 670	164, 980
600	30, 310	191, 460	221, 770
800	30, 310	239, 540	269, 850

[1] Total costs from tables 54 and 59.

Data from Texas Engineering Experiment Station.

[9] Brewster, John M. COMPARATIVE ECONOMIES OF DIFFERENT TYPES OF COTTONSEED OIL MILLS AND THEIR EFFECTS ON OIL SUPPLIES, PRICES, AND RETURNS TO GROWERS. U. S. Dept. Agr. Mktg. Res. Rpt. 54, 239 pp., illus. 1954.

TABLE 62.—*Investment requirements for equipment for soybean oil storage and shipping in soybean oil mills, by size of mill, 1952–53 season* [1]

Equipment unit	Unit cost			Size of mill (tons per day)																					
				25		50		100		150		200		300		400		500		600		800		1,000	
	Delivered	Installation	Total	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost
	Dollars	*Dollars*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*
Pumps for shipping oil in mills without tank scales [2]	1,480	420	1,900	1	1,900	1	1,900	1	1,900	1	1,900	1	1,900	1	1,900										
Tank scale, pumps and housing for shipping oil	5,355	3,065	8,420													1	8,420	1	8,420	1	8,420	1	8,420	1	8,420
Storage tanks:																									
23,000 gallons' capacity [3]	3,595	1,320	4,915	1	4,915	1	4,915																		
46,000 gallons' capacity [4]	7,040	2,395	9,435					1	9,435	1	9,435														
84,000 gallons' capacity [4]	8,655	3,045	11,700									1	11,700	1	11,700										
210,000 gallons' capacity [4]	12,145	4,410	16,555													1	16,555	1	16,555	1	16,555	1	16,555	1	16,555
105,000 gallons' capacity [5]	6,360	2,320	8,680																			1	8,680	1	8,680
Total cost of equipment					6,815		6,815		11,335		11,335		13,600		13,600		24,975		24,975		24,975		33,655		33,655

[1] Soybean oil storage requirements are equivalent to approximately 7 days oil production based on an average oil yield of 40 gallons (308 pounds) per ton of soybeans for both solvent and screw-press mills.

[2] Mills of sizes 300 tons per day and under, are assumed to use railroad track scales for weighing oil shipments (table 45).

[3] Includes only 1 tank and fire protection dike around it, and was designed fo be used only for mills of 25- and 50-ton-per-day processing capacity.

[4] Includes 2 tanks, manifold piping, and dike.

[5] Includes only 1 tank with piping and dike; was not designed to be used alone but only in addition to the 210,000 gallons storage unit to provide storage capacity in between 210,000 and 420,000 gallons.

Data from Texas Engineering Experiment Station.

TABLE 63.—*Description and investment requirements for buildings to house boilers, machine shops, and storerooms for soybean oil mills, by type and size of mill, 1952–53 season* [1]

Type and size of mill	Description						Cost		
	Area provided for					Building width	Delivered	Installation	Total
	Boilerhouse	Machine shop	Storeroom	Office [2]	Total				
Tons per day	*Square feet*	*Square feet*	*Square feet*	*Square feet*	*Square feet*	*Feet*	*Dollars*	*Dollars*	*Dollars*
Solvent:									
25	800	500	250	----------	1, 550	40	6, 750	2, 570	9, 320
50	800	600	300	----------	1, 700	40	7, 240	2, 760	10, 000
100	1, 600	700	350	----------	2, 650	40	10, 560	4, 070	14, 630
150	1, 600	800	400	----------	2, 800	40	11, 090	4, 280	15, 370
200	1, 600	1, 000	500	200	3, 300	40	12, 950	5, 080	18, 030
300	2, 000	1, 200	600	300	4, 100	50	14, 610	5, 700	20, 310
400	2, 000	1, 600	800	350	4, 750	50	16, 750	6, 480	23, 230
500	3, 000	2, 000	1, 000	400	6, 400	50	22, 200	8, 480	30, 680
600	3, 000	2, 400	1, 200	450	7, 050	50	24, 330	9, 240	33, 570
800	3, 000	2, 800	1, 400	500	7, 700	50	26, 480	10, 040	36, 520
1,000	3, 000	3, 200	1, 600	600	8, 400	50	28, 740	10, 900	39, 640
Screw press:									
25	640	500	250	----------	1, 390	32	6, 620	2, 300	8, 920
50	640	600	300	----------	1, 540	32	7, 120	2, 500	9, 620
100	960	700	350	----------	2, 010	32	8, 660	3, 140	11, 800
150	1, 500	800	400	----------	2, 700	50	9, 870	3, 870	13, 740
200	2, 000	1, 000	500	200	3, 700	50	13, 300	5, 210	18, 510
300	2, 000	1, 200	600	300	4, 100	50	14, 610	5, 700	20, 310
400	2, 000	1, 600	800	350	4, 750	50	16, 760	6, 480	23, 240
500	2, 000	2, 000	1, 000	400	5, 400	50	18, 910	7, 280	26, 190
600	2, 000	2, 400	1, 200	450	6, 050	50	21, 030	8, 050	29, 080
800	2, 000	2, 800	1, 400	500	6, 700	50	23, 140	8, 840	31, 980

[1] These buildings also include locker rooms whose costs are given in tables 66 and 67.

[2] Office is for supervisors or purchasing agent, or area may be used for other purpose.

Data from Texas Engineering Experiment Station.

Locker Rooms

The locker rooms were placed in the same building as the boiler room, machine shop, and storeroom. The units were made up to include partition walls, ceiling, plumbing fixtures, and other items, as well as the proportionate costs of the service building which should be borne by locker rooms. The total cost and area of the service building can be estimated by adding costs and areas for service buildings in table 63 to costs and areas of locker rooms in table 66.

The costs of four different sizes of rooms, based on the number of men served per day, are given in table 66. For the different-size mills, the total number of men served per day was calculated on the basis of total man-hours required per ton of beans given in table 17. One locker is allowed per employee. The total costs of locker rooms by type and size of mill are given in table 67.

ELECTRIC SUBSTATIONS

Costs of electric power substations are given in tables 69 and 70. For electric power facilities the assumption was made that 3-phase power from a public utility would be available at the mill boundary at 4,160 volts. Metering of power used and lighting protection were also assumed to be provided by the utility. All other facilities to transform this power to lower voltages and distribute it to the points of usage were included in the costs of the mills. Power at 4,160 volts was assumed to be supplied to 4,160/480-volt power centers located at load centers throughout the plant. By using a multiplicity of power centers, four different sizes were able to supply the power for any size of mill.

Electric power transformer requirements were calculated in a different manner from electric power billing demands. Thus transformers provided do not affect power costs. Most of the power used in a mill is for the elevator and the processing departments. Because of the large motors in the elevator department, the potential demand of this department is large and sufficient transformer capacity to supply it should be provided. In table 68 are shown the estimated demands of each of the cost units in the elevator department. Transformer capacity equivalent to the total of all of these potential demands was provided. This would leave a large surplus for normal operations because only infrequently would actual demand approach potential demand.

For the processing departments, transformer requirements were calculated by the following formula:

$$\frac{\text{Kilowatt-hour per ton} \times \text{TPD}}{24 \times 0.75 \times 0.85} = \text{kilowatt-hour per ton} \times \text{TPD} \times 0.065$$

TABLE 64.—*Description and investment requirements for steam generating equipment for soybean oil mills, by type and size of mill, 1952–53 season*

Type and size of mill	Description			Cost [3]		
	Steam flow required per hour [1]	Generators provided	Size of each generator [2] (steam flow per hour)[3]	Delivered	Installation	Total
Solvent: *Tons per day*	*Pounds*	*Number*	*Pounds*	*Dollars*	*Dollars*	*Dollars*
25	1,550	1	1,725	6,930	2,360	9,290
50	3,150	1	3,450	11,220	3,890	15,110
100	6,250	2	6,900	29,910	10,670	40,580
150	9,400	2	10,500	43,400	15,280	58,680
200	12,500	2	13,800	48,650	17,110	65,760
300	18,750	2	20,000	70,730	23,180	93,910
400	25,000	2	25,000	81,240	26,690	107,930
500	31,250	3	17,000	92,360	31,370	123,730
600	37,500	3	20,000	104,720	34,960	139,680
800	50,000	3	25,000	125,560	41,250	166,810
1,000	62,500	3	30,000	139,230	45,770	185,000
Screw press:						
25	750	1	1,050	6,470	2,220	8,690
50	1,500	1	1,725	6,940	2,370	9,310
100	3,000	2	3,450	19,520	6,530	26,050
150	4,500	2	5,200	23,410	8,340	31,750
200	6,000	2	6,900	29,580	10,590	40,170
300	9,000	2	10,500	39,900	13,650	53,550
400	12,000	2	13,800	48,590	17,190	65,780
500	15,000	2	17,000	50,730	18,060	68,790
600	18,000	2	20,000	68,380	22,390	90,770
800	24,000	2	25,000	80,460	26,500	106,960

[1] Based on 1,200 and 600 pounds of steam per ton of beans for solvent and screw-press processing, respectively, and for the mills operating at maximum rates.

[2] Generators for 25-ton-per-day solvent mill and 25- and 50-ton-per-day screw-press mills are designed to burn No. 2 fuel oil or gas. All other mills are designed to use either No. 6 fuel oil or gas.

[3] Includes cost of all necessary auxiliary equipment.

Data from Texas Engineering Experiment Station.

The 0.75 divisor provides for reserve capacity and for the impracticability of exactly balancing the load to all transformers. The 0.85 divisor allows for power factor less than unity.

Power for departments of the mill other than elevator and processing departments would be taken care of in the surpluses provided for these two departments.

Small power requirements will often be supplied by public utilities at 480 volts. For the 3 smallest mills, this was assumed to be the case and no transformers were provided.

Tables 69 and 70 give the costs of electric power substations for all sizes of solvent and screw-press mills. These costs include power centers for both the elevator and processing departments.

TRUCKS AND AUTOMOBILES

Costs allowed for trucks and automobiles are given in table 71. The estimates are for vehicles to be used around the plant. Automobiles for bean buyers or trucks for hauling beans or meal would be extra and are included in bean buying and meal selling expense. In the larger mills, larger trucks might be necessary which would be equivalent to fewer but larger vehicles than shown in table 71, but the total investment would be the same.

TABLE 65.—*Investment requirements for machine shop equipment and storeroom supplies for soybean oil mills, by size of mill, 1952–53 season*

Size of mill	Machine shop equipment	Storeoom supplies [1]	Total
Tons per day	*Dollars*	*Dollars*	*Dollars*
25	2,500	2,500	5,000
50	4,600	4,600	9,200
100	8,400	8,400	16,800
150	12,000	12,000	24,000
200	15,500	15,500	31,000
300	22,000	22,000	44,000
400	28,000	28,000	56,000
500	35,000	32,000	67,000
600	41,000	35,000	76,000
800	53,000	40,000	93,000
1,000	64,000	45,000	109,000

[1] Includes spare parts and all supplies for the mill and office, excluding fuel oil, solvent, and meal bags.

Data from Texas Engineering Experiment Station.

TABLE 66.—*Description and costs of locker rooms, by number of employees served per day, 1952–53 season*

Employees served per day	Area	Cost		
		Delivered	Installation	Total
	Square feet	*Dollars*	*Dollars*	*Dollars*
8 to 16	200	1,440	990	2,430
16 to 32	600	3,220	2,220	5,440
32 to 48	750	4,030	2,830	6,860
48 to 60	900	4,580	3,210	7,790

Data from Texas Engineering Experiment Station.

TABLE 67.—*Investment requirements of locker rooms and lockers for soybean oil mills, by type and size of mill, 1952–53 season*

Type and size of mill	Employees served per day [1]	Cost		
		Locker room	Lockers [2]	Total
Tons per day	*Number*	*Dollars*	*Dollars*	*Dollars*
Solvent:				
25	18	5,440	360	5,800
50	17	5,440	340	5,780
100	25	5,440	500	5,940
150	26	5,440	520	5,960
200	33	6,860	660	7,520
300	41	6,860	820	7,680
400	52	7,790	1,040	8,830
500	56	7,790	1,120	8,910
600	60	7,790	1,200	8,990
800	60	7,790	1,200	8,990
1,000	60	7,790	1,200	8,990
Screw press:				
25	10	2,430	200	2,630
50	10	2,430	200	2,630
100	17	5,440	340	5,780
150	19	5,440	380	5,820
200	20	5,440	400	5,840
300	32	6,860	640	7,500
400	38	6,860	760	7,620
500	43	6,860	860	7,720
600	44	6,860	880	7,740
800	51	7,790	1,020	8,810

[1] Based on total man-hours required per ton of soybeans (table 17).

[2] Total cost per locker is $20 (delivered cost, $17; installation cost, $3). Number of lockers is equivalent to the number of employees served per day.

Data from Texas Engineering Experiment Station.

MISCELLANEOUS SERVICE FACILITIES

The costs of miscellaneous service facilities for the entire mill, not included in other cost categories, are given in table 72. These costs for both types of mills provided for—

Steam piping from boilerhouse to buildings.
Potable water piping in the yard.
Sanitary sewer lines.
Yard lighting.
Storm sewer lines.
Roads and parking lots.
Fencing of solvent extraction area (solvent mill only).

INVENTORIES OF SUPPLIES

Inventories of fuel oil, meal bags, and solvent (for solvent mills) should be kept on hand to insure uninterrupted mill operations. A quantity of these materials would need to be on hand at the beginning of each season and so are considered to be part of the initial investment cost. The quantities and costs of the inventories provided are shown in table 73.

FIRE PROTECTION

Fire protection features of soybean oil mills were designed so as to be able to secure from insurance underwriters as favorable fire insurance rates as possible. The principles of design were taken mainly from recommendations in various bulletins published by the engineering division of the Associated Factory Mutual Fire Insurance Companies. The national fire codes of the National Fire Protection Association were also consulted. Equipment priced was that bearing the Underwriters Laboratories or Factory Mutuals seals of approval.

The fire protection features are shown in the property layouts for large and small mills in both solvent and screw-press types (figs. 5–8). As nearly as possible, the recommendations of the fire protection authorities were followed. These drawings also represent other desirable features of mill design such as spacing of buildings and tanks, dikes around tanks, and building partitions.

PROTECTION AGAINST FIRE HAZARDS

Fire hazards stemming from steam generators, dust, electrical system, and spacing of structures were minimized through the following precautions.

Steam Generators

The steam generators were provided with instruments for automatic operation, including controls to cut off the flow of fuel if the flame goes out.

Dust

For all dust-producing operations in elevators and processing departments, aspiration and dust collecting equipment was installed.

Electrical System

In the preparation, screw pressing, meal processing, and meal shipping areas, standardized electric motor control centers of dust resistant construction (NEMA Type 5) were used. Totally enclosed motors were provided, and lighting fixtures were dusttight (class II, group G).

TABLE 68.—*Estimated maximum electric power demand of receiving, storing, and drying equipment in northern soybean oil mills, by size of mill*

Equipment unit	Maximum electric power demand per unit	Size of mill (tons per day)																					
		25		50		100		150		200		300		400		500		600		800		1,000	
		Unit	Demand	Unit	Demand	Unit	Demand	Unit	Demand	Unit	Demand	Unit	Demand	Unit	Demand	Unit	Demand	Unit	Demand	Unit	Demand	Unit	Demand
	kw.	*Number*	*kw.*	*Number*	*kw.*	*Number*	*kw.*	*Number*	*kw.*	*Number*	*kw.*	*Number*	*kw.*	*Number*	*kw.*	*Number*	*kw.*	*Number*	*kw.*	*Number*	*kw.*	*Number*	*kw.*
Cleaners:																							
900 BPH (bushels per hour)	4.0							1	4.0	1	4.0												
1,800 BPH (bushels per hour)	8.0											1	8.0	1	8.0					2	16.0		
2,400 BPH (bushels per hour)	10.0															1	10.0	1	10.0			2	20.0
Dryers:																							
150 BPH, oil heated	9.0	1	9.0	1	9.0																		
300 BPH, oil heated	14.0					1	14.0																
500 BPH, oil heated	23.0							1	23.0	1	23.0												
1,000 BPH, oil heated	37.0											1	37.0	1	37.0	1	37.0	2	74.0	2	74.0	2	74.0
small truck dumper	9.0	1	9.0	1	9.0	1	9.0																
1 large truck dumper	27.0							1	27.0	1	27.0	1	27.0	1	27.0	1	27.0						
2 large truck dumpers	54.0																	1	54.0	1	54.0	1	54.0
1 railroad boxcar unloader	9.0	1	9.0	1	9.0	1	9.0	1	9.0														
2 railroad boxcar unloaders	19.0									1	19.0	1	19.0	1	19.0								
3 railroad boxcar unloaders	27.0															1	27.0						
Railroad boxcar dumper	39.0																	1	39.0	1	39.0	1	39.0
Bucket elevators:																							
4,000 BPH, 120-foot centers	15.0	1	15.0																				
4,000 BPH, 164-foot centers	20.0			2	40.0	2	40.0																
8,000 BPH, 164-foot centers	39.0							2	78.0	1	39.0	2	78.0	2	78.0	2	78.0						
15,000 BPH, 164-foot centers	73.0																	2	146.0	2	146.0	2	146.0
15,000 BPH, 212-foot centers	93.0									1	93.0	1	93.0	1	93.0	1	93.0						
25,000 BPH, 212-foot centers	154.0																	1	154.0	1	154.0	1	154.0
Terminals for distributing belt conveyors:																							
30-inch belt width	3.0							1	3.0			1	3.0	1	3.0	1	3.0						
36-inch belt width	4.0									1	4.0	1	4.0	1	4.0	1	4.0	1	4.0	1	4.0	1	4.0
42-inch belt width	5.0																	1	5.0	1	5.0	1	5.0
Belt conveyor increments:																							
24-inch belt width	.4					2	.8																
30-inch belt width	.6							6	3.6	4	2.4	12	7.2	18	10.8	30	18.0						
36-inch belt width	.9									4	3.6	6	5.4	9	8.1	15	13.5	38	34.2	52	46.8	64	57.6
42-inch belt width	1.2																	19	22.8	26	31.2	32	38.4
Total maximum electric power demand			42.0		67.0		[1] 73.0		[1] 148.0		215.0		[1] 282.0		[1] 288.0		[1] 311.0		543.0		570.0		592.0

[1] Rounded total.

Data from Texas Engineering Experiment Station.

TABLE 69.—*Investment requirements for electric power transformer substations for solvent soybean oil mills, by size of mill, 1952-53 season* [1]

Electric power transformer substations in rated capacity	Cost			Size of mill (tons per day)[1]															
	Delivered	Installation	Total	150		200		300		400		500		600		800		1,000	
				Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost
	Dollars	*Dollars*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*
150 kilovolt-amperes	3,880	710	4,590	1	4,590														
300 kilovolt-amperes	5,030	850	5,880			1	5,880	1	5,880	2	11,760							1	5,880
500 kilovolt-amperes	8,260	1,200	9,460	1	9,460	1	9,460					2	18,920			1	9,460		
750 kilovolt-amperes	10,120	1,400	11,520					1	11,520	1	11,520	1	11,520	3	34,560	3	34,560	4	46,080
Total cost of substations					14,050		15,340		17,400		23,280		30,440		34,560		44,020		51,960

[1] No substations were provided for mills of 25-through 100-ton-per-day sizes, as power at 480 volts was assumed to be supplied by the utility.

Data from Texas Engineering Experiment Station.

TABLE 70.—*Investment requirements for electric power transformer substations for screw-press soybean oil mills, by size of mill, 1952–53 season* [1]

Electric power transformer substations in rated capacity	Unit cost [2]	Size of mill (tons per day)													
		150		200		300		400		500		600		800	
		Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost
	Dollars	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*
150 kilovolt-amperes	4,590	1	4,590												
300 kilovolt-amperes	5,880			1	5,880	2	11,760	1	5,880	1	5,880				
500 kilovolt-amperes	9,460									1	9,460				
750 kilovolt-amperes	11,520	1	11,520	1	11,520	1	11,520	2	23,040	2	23,040	4	46,080	5	57,600
Total cost of substations			16,110		17,400		23,280		28,920		38,380		46,080		57,600

[1] No substations were provided for mills of 25- through 100-ton-per-day sizes as power at 480 volts was assumed to be supplied by the utility.

[2] Installed cost from table 69.

Data from Texas Engineering Experiment Station.

TABLE 71.—*Investment requirements for trucks and automobiles for soybean oil mills, by size of mill, 1952–53 season*

Size of mill	Quantity	Cost
Tons per day	*Number*	*Dollars*
25	1	2, 000
50	1	2, 000
100	2	4, 000
150	2	4, 000
200	3	6, 000
300	4	8, 000
400	5	10, 000
500	6	12, 000
600	7	14, 000
800	8	16, 000
1,000	9	18, 000

Data from Texas Engineering Experiment Station.

TABLE 72.—*Investment requirements for miscellaneous service facilities for soybean oil mills, by type and size of mill, 1952–53 season* [1]

Type and size of mill	Delivered	Installation	Total
Tons per day	*Dollars*	*Dollars*	*Dollars*
Solvent:			
25	4, 560	3, 970	8, 530
50	5, 300	4, 430	9, 730
100	6, 370	5, 090	11, 460
150	8, 290	6, 680	14, 970
200	9, 380	7, 630	17, 010
300	10, 730	8, 090	18, 820
400	13, 440	9, 010	22, 450
500	14, 780	9, 850	24, 630
600	15, 670	10, 860	26, 530
800	17, 330	11, 780	29, 110
1,000	18, 930	13, 020	31, 950
Screw press:			
25	3, 020	2, 910	5, 930
50	3, 430	3, 200	6, 630
100	4, 340	3, 770	8, 110
150	5, 380	4, 740	10, 120
200	6, 440	5, 570	12, 010
300	9, 140	6, 680	15, 820
400	9, 840	7, 140	16, 980
500	10, 540	7, 650	18, 190
600	12, 030	8, 700	20, 730
800	13, 460	9, 800	23, 260

[1] Miscellaneous service facilities include steam piping from boilerhouse to buildings, potable water piping in the yard, sanitary sewer lines, storm sewer lines, yard lighting, roads and parking lots and fencing of solvent extraction area (for solvent mills only).

Data from Texas Engineering Experiment Station.

In the solvent extraction department, all starters and controls for motors and for pump and cooling tower motors were in standardized control center structures enclosed in pressurized rooms adjacent to the solvent extraction buildings. The suction for the fans providing air pressure to these rooms was taken from stacks. The floors of these rooms were 5 feet above the ground. All lighting fixtures, wiring motors, and motor pushbuttons in the extraction building were explosionproof (class I, group D).

Electric power was assumed to be available at 4,160 volts from utility company substations. Nonflammable, liquid-filled, load-center power centers were provided (tables 69 and 70) for transformation to 480 volts. These transformers or power centers were situated outdoors at the approximate positions shown in figures 5 through 8. Dry-type transformers in the electric motor control centers were provided for single-phase, 120-volt power for lighting.

Spacing of Structures

In general, buildings were spaced at least 50 feet apart. In solvent mills, the solvent extraction building was spaced 100 feet from all other important structures except the water cooling tower and pumphouse. A fence around the solvent extraction building was 50 feet away from the building and 25 feet from other related structures such as the cooling tower. The gravity water tank and the fire pump house were 50 feet or more away from other structures. When both gravity tank and the fire pump were provided, they were situated as nearly as possible at opposite ends of the fire water mains. Solvent unloading stations were at least 100 feet from important buildings. Above ground solvent, fuel oil, and soybean oil storage tanks were surrounded by dikes and were spaced from other structures according to recommendations of the fire protection authorities.

FIRE PROTECTION FACILITIES

For fire protection, cost units were made up for all of the fire protection equipment which a mill might require. These are shown in tables 74 and 75 and specify the quantities of these units for all mills. Table 76 contains estimates for small hose portable extinguishers and miscellaneous fire protection facilities. Tables 77 and 78 give the requirements and costs of automatic sprinkler systems for solvent and screw-press mills.

The fire protection facilities were designed on the assumption that municipal water would be available to fill the water reservoirs but no municipal fire mains would be available. Thus the mill would have to provide its own primary and secondary sources of supply for fire protection.

Elevated Water Tanks and Fire Pumps

These facilities were provided as primary and secondary sources of water supply respectively for the operation of automatic sprinklers, fire hydrants, and hose racks within buildings.

Water Mains

The position of the water mains for fire protection were as shown in figures 5 through 8. The plan was for the mains to be used for no other purpose than fire protection. For all sizes and

TABLE 73.—*Investment requirements for inventories of supplies for soybean oil mills, by type and size of mills, 1952–53 season*

Type and size of mill	Solvent [1]		Fuel oil [2]		Meal bags [3]		Total cost
	Railroad carloads	Cost	Railroad carloads	Cost	Railroad carloads [4]	Cost	
Tons per day	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Dollars*
Solvent:							
25	1	1, 520	1	880	⅓	2, 700	5, 100
50	1	1, 520	1	480	⅓	2, 700	4, 700
100	1	1, 520	2	960	⅔	5, 400	7, 880
150	1	1, 520	2	960	⅔	5, 400	7, 880
200	1	1, 520	3	1, 440	⅔	5, 400	8, 360
300	2	3, 040	5	2, 400	1	8, 100	13, 540
400	2	3, 040	7	3, 360	1	8, 100	14, 500
500	2	3, 040	8	3, 840	1⅓	10, 800	17, 680
600	2	3, 040	10	4, 800	1⅓	10, 800	18, 640
800	3	4, 560	13	6, 240	2	16, 200	27, 000
1,000	3	4, 560	16	7, 680	2⅓	18, 900	31, 140
Screw press:							
25			1	880	⅓	2, 700	3, 580
50			1	880	⅓	2, 700	3, 580
100			1	480	⅔	5, 400	5, 880
150			1	480	⅔	5, 400	5, 880
200			1	480	⅔	5, 400	5, 880
300			2	960	1	8, 100	9, 060
400			3	1, 440	1	8, 100	9, 540
500			4	1, 920	1⅓	10, 800	12, 720
600			5	2, 400	1⅓	10, 800	13, 200
800			6	2, 880	2	16, 200	19, 080

[1] Based on 8,000 gallons per carload costing 19 cents per gallon.

[2] Based on 8,000 gallons per carload; 25-ton-per-day solvent mill and 25- and 50-ton-per-day screw-press mills using No. 2 fuel oil costing 11 cents per gallon and all other mills using No. 6 fuel oil costing 6 cents per gallon.

[3] Based on 45,000 bags per carload costing 18 cents per bag.

[4] Mills up through size 200 tons per day would probably receive all meal bags in truckload lots averaging approximately 15,000 bags, which would be equivalent to the number of railroad carloads shown.

types of mills, the water mains were of 8-inch size. All branches, from the mains to fire hydrants or to automatic sprinkler distribution points, were of 6-inch size.

Hydrants and Hose Houses

Hydrants with hose houses were spaced as shown on the drawings from 200 to 300 feet apart along the water main and 50 feet from buildings when possible. Six-inch piping connected each hydrant to the water main. Fire hose racks with small hose were spaced every 50 to 100 feet apart along one wall of the processing, solvent extraction, and service buildings. Hose racks were also provided in the soybean storage silos.

Indicator Post Control Valves

The positions of indicator post valves are shown on the drawings. In general, one valve was provided with every wet pipe sprinkler connection to the water main. Valves were provided with the fire pump and gravity tank connections to the main.

Partitions and Fire Walls

In the bean processing buildings for both types of mills, partitions of the same construction as the buildings were provided to separate meal shipping, bagged meal storage, and meal processing areas.

The boiler room was separated from the remainder of the service building by a brick firewall with standard fire doors.

Automatic sprinkler systems

Description of the automatic sprinkler systems along with the estimated costs are given in tables 77 and 78. Wet pipe systems were provided for heated bean processing areas, and dry pipe systems were provided for the unheated areas of meal shipping and bagged meal storage. The numbers of heads for ordinary hazard areas were estimated on the basis of 110 square feet per head, assuming the use of spray-type sprinkler heads. For extra-hazard areas (solvent extraction department), sprinklers were estimated on the basis of 65 square feet per head.

The numbers of sprinkler heads were estimated by rule-of-thumb methods as follows. For flake preparation and meal processing areas in solvent mills, 2 times the ground floor area (because of second floor grating over most of the area) divided by 110, gave the number of heads.

For bean preparation, screw pressing, and meal processing in screw-press mills, the numbers of

TABLE 74.—*Investment requirements for fire protection equipment for solvent soybean oil mills, by size of mill, 1952-53 season*

Equipment unit	Unit cost			Size of mill (tons per day)																					
	Delivered	Installation	Total	25		50		100		150		200		300		400		500		600		800		1,000	
				Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost
	Dollars	*Dollars*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*
Elevated water tank, 50,000 gallons' capacity	19,900	5,850	25,750	1	25,750	1	25,750	1	25,750	1	25,750	1	25,750	1	25,750	1	25,750								
Elevated water tank, 100,000 gallons' capacity	26,000	7,660	33,660															1	33,660	1	33,660	1	33,660	1	33,660
Fire pump, electric, 750 gpm (gallons per minute)	6,500	1,200	7,700	1	7,700	1	7,700																		
Fire pump, electric, 1,000 gpm	6,800	1,300	8,100					1	8,100	1	8,100	1	8,100	1	8,100	1	8,100								
Fire pump, electric and gasoline, 1,500 gpm	15,200	3,200	18,400															1	18,400	1	18,400	1	18,400	1	18,400
Fire pump supply tank, 150,000 gallons' capacity	6,850	2,940	9,790	1	9,790	1	9,790	1	9,790	1	9,790	1	9,790	1	9,790	1	9,790								
Fire pump supply tank, 200,000 gallons' capacity	8,250	3,500	11,750															1	11,750	1	11,750	1	11,750	1	11,750
Fire pump house, small	730	750	1,480	1	1,480	1	1,480	1	1,480	1	1,480	1	1,480	1	1,480	1	1,480								
Fire pump house, large	1,140	1,130	2,270															1	2,270	1	2,270	1	2,270	1	2,270
Fire hydrant and hose house [1]	500	50	550	4	2,200	4	2,200	4	2,200	6	3,300	6	3,300	6	3,300	6	3,300	6	3,300	6	3,300	6	3,300	6	3,300
Indicator post control valve, 8-inch	170	77	247	1	247	1	247	1	247	5	1,235	5	1,235	5	1,235	5	1,235	5	1,235	5	1,235	5	1,235	5	1,235
Water main, 6-inch, per foot	[2] 2	[2] 1	[2] 3	206	618	206	618	206	618	215	645	215	645	215	645	215	645	215	645	215	645	215	645	215	645
Water main, 8-inch, per foot	[3] 3	[3] 2	[3] 5	350	1,750	350	1,750	350	1,750	650	3,250	670	3,350	820	4,100	840	4,200	900	4,500	920	4,600	940	4,700	980	4,900
Fire wall for 40-foot-wide service building	1,370	1,680	3,050	1	3,050	1	3,050	1	3,050	1	3,050	1	3,050												
Fire wall for 50-foot-wide service building	1,670	2,080	3,750											1	3,750	1	3,750	1	3,750	1	3,750	1	3,750	1	3,750
Connection to water main for soybean storage			3,000	1	3,000	1	3,000	1	3,000	1	3,000	1	3,000	1	3,000	1	3,000	1	3,000	1	3,000	1	3,000	1	3,000
Total equipment cost					55,585		55,585		55,985		59,600		59,700		61,150		61,250		82,510		82,610		82,710		82,910

[1] Costs include fire hydrant, wooden hose house, and all the equipment such as hose, play pipes, wrenches, etc., specified for approved hose houses. Cost of 6-inch connecting piping to water main was added as shown.

[2] Unrounded costs used in calculations were: Delivered, $1.80; installation, $1.40; and total, $3.20.

[3] Unrounded costs used in calculations were: Delivered, $2.60; installation, $1.80; and total, $4.40.

Data from Texas Engineering Experiment Station.

TABLE 75.—*Investment requirements for fire protection equipment for screw-press soybean oil mills, by size of mill, 1952–53 season*

Equipment unit	Unit cost [1]	Size of mill (tons per day)																			
		25		50		100		150		200		300		400		500		600		800	
		Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost
	Dollars	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*	*Number*	*Dollars*
Elevated water tank, 50,000 gallons' capacity	25,750	1	25,750	1	25,750							1	25,750	1	25,750	1	25,750				
Elevated water tank, 100,000 gallons' capacity	33,660					1	33,660	1	33,660	1	33,660							1	33,660	1	33,660
Tank filling pump for 50,000-gallon tank, 105 gpm (gallons per minute)[2]	1,510	1	1,510	1	1,510																
Tank filling pump for 100,000-gallon tank, 210 gmp [3]	1,930					1	1,930	1	1,930	1	1,930										
Fire pump, electric, 750 gpm	7,700											1	7,700	1	7,700	1	7,770				
Fire pump, electric and gasoline, 1,500 gpm	18,400																	1	18,400	1	18,400
Fire pump supply tank, 150,000 gallons' capacity	9,790											1	9,790	1	9,790	1	9,790				
Fire pump supply tank, 200,000 gallons' capacity	11,750																	1	11,750	1	11,750
Fire pump house, small	1,480											1	1,480	1	1,480	1	1,480				
Fire pump house, large	2,270																	1	2,270	1,	2,270
Fire hydrant and hose house [4]	550	4	2,200	4	2,200	4	2,200	6	3,300	6	3,300	6	3,330	6	3,330	6	3,330	6	3,300	6	3,300
Indicator post control valve, 8-inch	247	1	247	1	247	1	247	5	1,235	5	1,235	5	1,235	5	1,235	5	1,235	5	1,235	5	1,235
Water main, 6-inch, per foot	[5] 3	248	744	248	744	248	744	163	489	163	489	163	489	163	489	163	489	163	489	163	489
Water main, 8-inch, per foot	[6] 5	330	1,650	330	1,650	330	1,650	828	4,140	868	4,340	868	4,340	968	4,840	1,028	5,140	1,068	5,340	1,208	6,040
Fire wall for 32-foot wide service building [7]	2,450	1	2,450	1	2,450	1	2,450														
Fire wall for 50-foot wide service building	3,750							1	3,750	1	3,750	1	3,750	1	3,750	1	3,750	1	3,750	1	3,750
Connection to water main for soybean storage	3,000	1	3,000	1	3,000	1	3,000	1	3,000	1	3,000	1	3,000	1	3,000	1	3,300	1	3,000	1	3,000
Total equipment cost			37,551		37,551		45,881		51,504		51,704		60,834		61,334		61,634		83,194		83,894

[1] Costs same as for solvent mills given in table 74 except for tank filling pumps and firewall for 32-foot-wide service building.

[2] Delivered cost, $1,040; installation cost, $470.

[3] Delivered cost, $1,340; installation cost, $590.

[4] Costs include fire hydrant, wooden hose house, and all of the equipment such as hose, playpipes, wrenches, etc., specified for approved hose houses. Cost of 6-inch connecting piping to water main was added as shown.

[5] Unrounded cost used in calculations was $3.20.

[6] Unrounded cost used in calculations was $4.40.

[7] Delivered cost, $1,100; installation cost, $1,350.

Data from Texas Engineering Experiment Station.

heads were estimated on the basis of 1 for each 110 square feet of ground-floor area, plus 20 percent additional in mills below 400 TPD, and 10 percent additional for mills above 400 TPD for extra sprinklers around cracked bean dryers, cake coolers, and hammer mills.

For meal bagging and shipping and bagged meal storage areas, sprinklers were estimated on the basis of 1 head per 110 square feet of ground floor area. Sprinklers for bucket elevator housing (adjacent to meal shipping) were included with estimates for meal shipping. Sprinklers for loading docks were also added to meal shipping on the basis of 1 head per 10 feet of dock.

For solvent extraction buildings, in 25- through 200-TPD mills, sprinklers were estimated on the basis of 1.5 times the number of heads for the ground-floor area at 65 square feet per head. In 300 through 1,000-ton-per-day mills, sprinklers were estimated on the basis of 1 head per 65 square feet of area for the top floor of the building, plus the estimated areas covered by grating floor for all of the other floors. This estimate was based on the assumption that sprinklers would be necessary underneath all upper floors and underneath the entire roof area. Some floors would be solid concrete instead of grating; however, the design was not carried to the detail of differentiating floor construction. Buildings of different dimensions housing equipment of different manufacture might require different numbers of sprinkler heads; however only approximate estimates were made.

The costs in tables 77 and 78 include sprinklers, 6-inch lead-in piping from the water main, and indicator post valves for each lead-in pipe. In addition wet pipe systems include water flow alarms, and dry pipe systems include dry pipe valves, accessories, and heated enclosures.

Fire Protection Features of Soybean Storage Elevators

The recommended practices state that for bean storage elevators should have small hose available at all operating levels. This hose should be supplied by standpipes, which are dry in unheated areas. Also remote control devices, to admit water to the standpipe, should be provided at hose stations. This item of the fire protection system was not designed in detail. Instead the allowances given in tables 77 and 78 were made to provide for standpipe, connection to main, and remote control operating devices. The allowances for small hose are given in table 76.

OFFICES AND ANALYTICAL LABORATORIES

The costs of buildings and equipment for offices and analytical laboratories in soybean oil mills are given in table 79. The costs were not estimated in detail because these facilities could vary so much with local conditions that nothing would be added to the accuracy of the estimates by preparing them in detail.

TABLE 76.—*Investment requirements for small hose, portable fire extinguishers, and miscellaneous fire protection equipment for different types of soybean oil mills, by type and size of mill, 1952–53 season*

Size of mill	Solvent mills	Screw-press mills
Tons per day	*Dollars*	*Dollars*
25	1, 200	900
50	1, 200	900
100	1, 200	900
150	1, 300	1, 000
200	1, 500	1, 100
300	2, 000	1, 300
400	2, 300	1, 500
500	2, 700	1, 600
600	3, 200	1, 800
800	3, 400	2, 000
1,000	3, 600	----------

Data from Texas Engineering Experiment Station.

The estimated costs were sufficient to provide for modest facilities of noncombustible construction.

ALLOWANCES FOR RAILROAD TRACKS

The costs allowed for railroad tracks shown in tables 82 and 83 are only order-of-magnitude figures. The arrangement of railroad tracks in a mill is a complicated problem, involving working out track and switch arrangements. Since the costs are so dependent upon local factors, they were not estimated in detail. Differences between solvent and screw-press mills would not be significant.

LAND

Land requirements and costs for solvent and screw-press mills are given in table 80. The acreages shown are approximate minimums for the requirements of the different sizes of mills. Both the length and width of the property (figs. 5–8) were used in estimating the requirements. Building and machinery layouts different from those shown in the property-layout drawings might require less land. However, actual mills might provide more railroad trackage than was allowed, and would probably include land for future expansion, thus requiring more acreage than estimated for the model mills. The $1,000 per acre includes the cost of an average amount of preparation which might be necessary such as clearing or filling.

TOTAL PLANT INVESTMENTS

The investment requirements of the various departments of complete solvent and screw-press mills are totaled and shown in tables 82 and 83. Although total investment increases directly with size of mill, the proportionate costs of the separate departments vary as shown in table 81. In solvent mills the processing department accounts for the highest percentage of total costs for all mills up

TABLE 77.—*Description and investment requirements for automatic sprinkler systems for solvent soybean oil mills, by size of mill, 1952–53 season* [1]

Size of mill	Flake preparation and meal processing department (wet-type sprinklers)			Meal bagging and shipping department (dry-type sprinklers)			Bagged meal storage department (dry-type sprinklers) [2]			Solvent extraction department (wet-type sprinklers) [3]			Total cost
	Area	Sprinkler heads	Installed cost	Area	Sprinkler heads	Installed cost	Area	Sprinkler heads	Installed cost	Area	Sprinkler heads	Installed cost	
Tons per day	*Square feet*	*Number*	*Dollars*	*Square feet*	*Number*	*Dollars*	*Square feet*	*Number*	*Dollars*	*Square feet*	*Number*	*Dollars*	*Dollars*
25	2, 280	40	2, 010	760	11	2, 670	1, 140	12	504	1, 064	27	1, 540	6, 724
50	2, 280	40	2, 010	760	11	2, 670	1, 900	20	840	1, 064	27	1, 540	7, 060
100	2, 280	40	2, 010	760	11	2, 670	3, 040	32	1, 344	2, 080	49	2, 280	8, 304
150	1, 900	33	1, 740	1, 520	20	3, 040	1, 520	16	672	2, 600	60	2, 620	8, 072
200	2, 280	40	2, 010	1, 520	20	3, 040	1, 520	16	672	2, 800	65	2, 770	8, 492
300	3, 640	66	2, 800	1, 560	20	3, 040	2, 080	20	840	2, 116	140	4, 650	11, 330
400	4, 160	77	3, 200	1, 560	20	3, 040	2, 080	20	840	2, 304	151	4, 900	11, 980
500	5, 200	95	3, 620	2, 376	34	3, 500	2, 080	20	840	2, 704	178	6, 020	13, 980
600	5, 720	104	3, 860	2, 376	34	3, 500	2, 080	20	840	3, 720	248	7, 600	15, 800
800	6, 240	113	4, 080	2, 376	34	3, 500	2, 080	20	840	4, 092	270	8, 100	16, 520
1,000	7, 245	131	4, 510	2, 376	34	3, 500	2, 080	20	840	4, 340	286	8, 480	17, 330

[1] Investment requirements include lead-in piping, control valves, and other accessories.

[2] Sprinklers are controlled by the same dry-pipe sprinkler valve which is included in costs for the meal bagging and shipping department.

[3] Size and layout of solvent-extraction area will vary depending upon the type of equipment. The data shown are merely representative of 1 possible series of designs.

Data from Texas Engineering Experiment Station.

TABLE 78.—*Description and investment requirements for automatic sprinkler systems for screw-press soybean oil mills, by size of mill, 1952–53 season* [1]

Size of mill	Soybean preparation, oil extraction, and meal processing dept. (wet-type sprinklers)			Meal bagging and shipping dept. (dry-type sprinklers)			Bagged meal storage dept. (dry-type sprinklers)[2]			Total cost
	Area	Sprinkler heads	Installed cost	Area	Sprinkler heads	Installed cost	Area	Sprinkler heads	Installed cost	
Tons per day	*Square feet*	*Number*	*Dollars*	*Square feet*	*Number*	*Dollars*	*Square feet*	*Number*	*Dollars*	*Dollars*
25	1, 920	22	1, 370	640	10	2, 640	1, 280	12	520	4, 530
50	2, 560	29	1, 620	640	10	2, 640	1, 920	18	780	5, 040
100	3, 520	40	2, 010	640	10	2, 640	3, 200	30	1, 300	5, 950
150	6, 000	66	2, 800	1, 800	25	3, 170	1, 800	18	750	6, 720
200	7, 200	80	3, 170	1, 800	25	3, 170	1, 800	18	750	7, 090
300	9, 600	102	3, 770	1, 800	25	3, 170	2, 400	24	1, 000	7, 940
400	10, 200	106	3, 870	1, 800	25	3, 170	2, 400	24	1, 000	8, 040
500	12, 000	120	4, 160	1, 800	32	3, 440	2, 400	24	1, 000	8, 600
600	13, 200	131	4, 420	1, 800	32	3, 440	2, 400	24	1, 000	8, 860
800	17, 400	175	5, 390	1, 800	32	3, 440	2, 400	24	1, 000	9, 830

[1] Investment requirements include lead-in piping, control valves, and other accessories.

[2] Sprinklers are controlled by the same dry-pipe sprinkler valve which is included in costs for the meal bagging and shipping department.

Data from Texas Engineering Experiment Station.

through the 400 tons per day size, whereas in larger mills the elevator department represents the highest cost. However, the elevator department is the highest cost for all screw-press mills with the processing department ranking next, representing about one-third of total investment.

Fire protection investment was a much larger percentage of total investment for small mills than for the biggest mills because it was deemed advisable to provide all mills with the same degree of fire protection.

Table 84 shows the investment requirements per bushel of soybeans processed annually for the elevator and processing departments and the complete mills. The greatest savings in investment per bushel of capacity occur in increasing the size of mill from 25 to 50 tons per day and from 50 to 100 tons per day for both types of mills. The least savings occur when increasing the size from 400 to 500 and from 500 to 600 tons per day. The latter is due mainly to the increased cost of the elevator department, because at 600 tons per day, much more expensive unloading equipment is used. Changing from 400 to 500 tons per day involved increasing bean storage capacity from the equivalent of 80 to 100 days' operation requirements.

Table 84 shows also the investment ratio of the solvent mill to the screw-press mill: the ratio de-

TABLE 79.—*Description and investment requirements of buildings and equipment for offices and analytical laboratories in soybean oil mills, by size of mill, 1952–53 season*

Type and size of mill	Building area	Investment			
		Building	Office equipment	Laboratory equipment	Total
Tons per day	*Square feet*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
25	600	5, 500	3, 000	----------	8, 500
50	880	8, 800	4, 500	----------	13, 300
100	1, 300	14, 000	6, 700	----------	20, 700
150	1, 650	18, 500	8, 400	5, 000	31, 900
200	1, 950	22, 500	10, 000	5, 000	37, 500
300	2, 500	29, 500	12, 500	6, 000	48, 000
400	2, 900	36, 000	14, 700	7, 000	57, 700
500	3, 300	42, 000	16, 700	8, 000	66, 700
600	3, 700	47, 500	18, 500	9, 000	75, 000
800	4, 400	58, 000	22, 000	9, 000	89, 000
1,000	5, 000	67, 000	25, 000	10, 000	102, 000

Data from Texas Engineering Experiment Station.

creases with size of mill from 140 percent for the 25-TPD size to 104 percent for the 800 TPD size.

Total plant investments for both types of mills producing bulk meal only are given in table 85.

TABLE 80.—*Description and investment requirements for land for solvent and screw-press soybean oil mills, by type and size of mill, 1952–53 season*

Type and size of mill	Length	Width	Acreage	Total cost [1]
Solvent: *Tons per day*	*Feet*	*Feet*	*Number*	*Dollars*
25	622	309	5	5, 000
50	665	309	5	5, 000
100	742	321	6	6, 000
150	776	517	9	9, 000
200	857	517	10	10, 000
300	919	577	12	12, 000
400	1, 099	579	15	15, 000
500	1, 159	597	16	16, 000
600	1, 179	623	17	17, 000
800	1, 230	678	19	19, 000
1,000	1, 291	678	20	20, 000
Screw press:				
25	537	248	3	3, 000
50	600	248	4	4, 000
100	717	248	4	4, 000
150	684	529	9	9, 000
200	785	529	10	10, 000
300	929	529	12	12, 000
400	1, 049	529	13	13, 000
500	1, 099	543	14	14, 000
600	1, 129	553	15	15, 000
800	1, 240	608	18	18, 000

[1] Equivalent to $1,000 per acre.

Data from Texas Engineering Experiment Station.

TABLE 81.—*Investment requirements of major soybean oil mill departments as proportions of total mill investment, by type and size of mill, 1952–53 season*

Type and size of mill	Departments					
	Elevator	Processing	Product storage and shipping	Fire protection	All other	Total
Tons per day	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Solvent:						
25	26	46	6	10	12	100
50	29	45	6	8	12	100
100	32	43	5	6	14	100
150	35	39	7	5	14	100
200	37	38	7	4	14	100
300	36	40	7	3	14	100
400	36	40	7	3	14	100
500	39	37	8	3	13	100
600	46	34	6	2	12	100
800	47	34	6	2	11	100
1,000	47	34	6	2	11	100
Screw press:						
25	36	30	9	10	15	100
50	38	31	9	8	14	100
100	40	33	7	6	14	100
150	40	33	8	5	14	100
200	41	32	9	4	14	100
300	39	35	8	4	14	100
400	39	36	8	3	14	100
500	42	36	8	2	12	100
600	49	31	7	2	11	100
800	49	32	6	2	11	100

TABLE 82.—*Total investment requirements for different departments of solvent soybean oil mills, by size of mill, 1952–53 season*

Size of mill	Elevator department	Processing department			Product storage and shipping department			Service department							Fire protection department				Office and analytical laboratory	Railroad tracks	Land	Total
		Flake preparation and meal processing	Oil extraction	Total	Meal bagging, storage, and shipping	Oil storage and shipping	Total	Boiler room, machine shop, and storeroom	Locker room	Electric power substation	Trucks and automobiles	Miscellaneous equipment	Inventories of supplies	Total	Major equipment	Automatic sprinkler system	Miscellaneous equipment	Total				
Tons per day	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
25	155,810	109,230	169,360	278,590	31,690	6,815	38,505	23,610	5,800	--------	2,000	8,530	5,100	45,040	55,585	6,724	1,200	63,509	8,500	15,000	5,000	609,954
50	219,620	114,180	221,670	335,850	39,200	6,815	46,015	34,310	5,780	--------	2,000	9,730	4,700	56,520	55,585	7,060	1,200	63,845	13,300	16,000	5,000	756,150
100	349,780	144,770	321,050	465,820	47,180	11 335	58,515	72,010	5,940	--------	4,000	11,460	7,880	101,290	55,985	8,304	1,200	65,489	20,700	18,000	6,000	1,085,594
150	522,330	194,210	393,690	587,900	95,310	11,335	106,645	98,050	5,960	14,050	4,000	14,970	7,880	144,910	59,600	8,072	1,300	68,972	31,900	30,000	9,000	1,501,657
200	683,240	235,235	468,810	704,045	127,310	13,600	140,910	114,790	7,520	15,340	6,000	17,010	8,360	169,020	59,700	8,492	1,500	69,692	37,500	40,000	10,000	1,854,407
300	840,660	315,935	622,140	938,075	159,764	13,600	173,364	158,220	7,680	17,400	8,000	18,820	13,540	223,660	61,150	11,330	2,000	74,480	48,000	55,000	12,000	2,365,239
400	1,019,130	389,835	737,800	1,127,635	179,356	24,975	204,331	187,160	8,830	23,280	10,000	22,450	14,500	266,220	61,250	11,980	2,300	75,530	57,700	65,000	15,000	2,830,546
500	1,391,870	462,420	838,220	1,300,640	242,146	24,975	267,121	221,410	8,910	30,440	12,000	24,630	17,680	315,070	82,510	13,980	2,700	99,190	66,700	70,000	16,000	3,526,591
600	2,139,690	525,750	1,035,120	1,560,870	256,186	24,975	281,161	249,250	8,990	34,560	14,000	26,530	18,640	351,970	82,610	15,800	3,200	101,610	75,000	85,000	17,000	4,612,301
800	2,576,310	654,635	1,209,130	1,863,765	304,266	33,655	337,921	296,330	8,990	44,020	16,000	29,110	27,000	421,450	82,710	16,520	3,400	102,630	89,000	90,000	19,000	5,500,076
1,000	2,938,870	784,115	1,365,510	2,149,625	332,474	33,655	366,129	333,640	8,990	51,960	18,000	31,950	31,140	475,680	82,910	17,330	3,600	103,840	102,000	95,000	20,000	6,251,144

Data from Texas Engineering Experiment Station.

TABLE 83.—*Total investment requirements for different departments of screw-press soybean oil mills, by size of mill, 1952–53 season*

Size of mill	Elevator department	Processing department (soybean preparation, oil extraction, and meal processing)	Product storage and shipping department			Service department							Fire protection department				Office and analytical laboratory	Railroad tracks	Land	Total
			Meal bagging, storage and shipping	Oil storage and shipping	Total	Boiler room, machine shop, and storeroom	Locker room	Electric power substation	Trucks and automobiles	Miscellaneous equipment	Inventories of supplies	Total	Major equipment	Automatic sprinkler system	Miscellaneous equipment	Total				
Tons per day	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
25	155,810	131,210	34,460	6,815	41,275	22,610	2,630	--------	2,000	5,930	3,580	36,750	37,551	4,530	900	42,981	8,500	15.000	3.000	434,526
50	219,620	172,690	42,230	6,815	49,045	28,130	2,630	--------	2,000	6,630	3,580	42,970	37,551	5,040	900	43,491	13,300	16,000	4.000	561,116
100	349,780	282,190	52,490	11,335	63,825	54,650	5,780	--------	4,000	8,110	5,880	78,420	45,881	5,950	900	52,731	20.700	18,000	4.000	869,646
150	522,330	426,350	102,238	11,335	113,573	69,490	5,820	16,110	4,000	10,120	5,880	111,420	51,504	6,720	1,000	59,224	31,900	30 000	9,000	1,303,797
200	683,240	536,085	134,238	13,600	147,838	89,680	5,840	17,400	6.000	12,010	5,880	136,810	51,704	7,090	1,100	59,894	37,500	40,000	10,000	1,651,367
300	840,660	759,775	165,664	13,600	179,264	117,860	7,500	23,280	8,000	15,820	9,060	181,520	60,834	7,940	1,300	70,074	48,000	55,000	12,000	2,146,293
400	1,019,130	941,935	185,084	24,975	210,059	145,020	7,620	28,920	10,000	16,980	9,540	218,080	61,334	8,040	1,500	70,874	57,700	65,000	13,000	2,595,778
500	1,391,870	1,175,990	248,046	24,975	273,021	161,980	7,720	38,380	12,000	18,190	12,720	250,990	61,634	8,600	1,600	71,834	66,700	70,000	14,000	3,314,405
600	2,139,690	1,361,320	262,086	24,975	287,061	195,850	7,740	46,080	14,000	20,730	13,200	297,600	83,194	8,860	1,800	93,854	75,000	85,000	15,000	4,354,525
800	2,576,310	1,708,065	310,166	33,655	343,821	231,940	8,810	57,600	16,000	23,260	19,080	356,690	83,894	9,830	2,000	95,724	89,000	90,000	18,000	5,277,610

Data from Texas Engineering Experiment Station.

TABLE 84.—*Investment requirements per bushel of soybeans processed by soybean oil mills, by type and size of mill, 1952–53 season* [1]

Size of mill	Soybeans processed annually	Processing departments					Elevator department		All departments				
		Solvent mill		Screw-press mill		Ratio of solvent mill to screw-press mill	Amount	Decrease	Solvent mill		Screw-press mill		Ratio of solvent mill to screw-press mill
		Amount	Decrease [2]	Amount	Decrease [2]				Amount	Decrease [2]	Amount	Decrease [2]	
Tons per day	*1,000 bu.*	*Dollars*	*Percent*	*Dollars*	*Percent*	*Percent*	*Dollars*	*Percent*	*Dollars*	*Percent*	*Dollars*	*Percent*	*Percent*
25	275	1. 013	0	0. 477	0	212	0. 567	0	2. 218	0	1. 580	0	140
50	550	. 611	40	. 314	34	195	. 399	30	1. 375	38	1. 020	35	135
100	1, 100	. 423	31	. 257	18	165	. 318	20	. 987	28	. 791	22	125
150	1, 650	. 356	16	. 258	0	138	. 317	0	. 910	8	. 790	0	115
200	2, 200	. 320	10	. 244	5	131	. 311	2	. 843	7	. 751	5	112
300	3, 300	. 284	11	. 230	6	123	. 255	18	. 717	15	. 650	13	110
400	4, 400	. 256	10	. 214	7	120	. 232	9	. 643	10	. 590	9	109
500	5, 500	. 236	8	. 214	0	110	. 253	−9	. 641	0	. 603	−2	106
600	6, 600	. 236	0	. 206	4	115	. 324	−28	. 699	−9	. 660	−9	106
800	8, 800	. 212	10	. 194	6	109	. 292	10	. 625	11	. 600	10	104
1,000	11, 000	. 195	8	---	---	---	. 267	9	. 568	9	---	---	---

[1] For production of bagged and bulk meal.
[2] Each preceding mill used as base for following size mill.

TABLE 85.—*Total investment requirements for solvent and screw-press soybean oil mills, by type and size of mill, 1952–53 season* [1]

Size of mill	Solvent mill	Screw-press mill
Tons per day	*Dollars*	*Dollars*
25	611, 624	433, 616
50	751, 450	553, 576
100	1, 094, 214	873, 146
150	1, 467, 527	1, 268, 529
200	1, 820, 277	1, 616, 099
300	2, 315, 335	2, 094, 119
400	2, 792, 440	2, 555, 574
500	3, 434, 995	3, 220, 539
600	4, 563, 455	4, 303, 409
800	5, 445, 830	5, 221, 094
1,000	6, 194, 070	----------

[1] For production of bulk meal only.

Data from Texas Engineering Experiment Station.

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